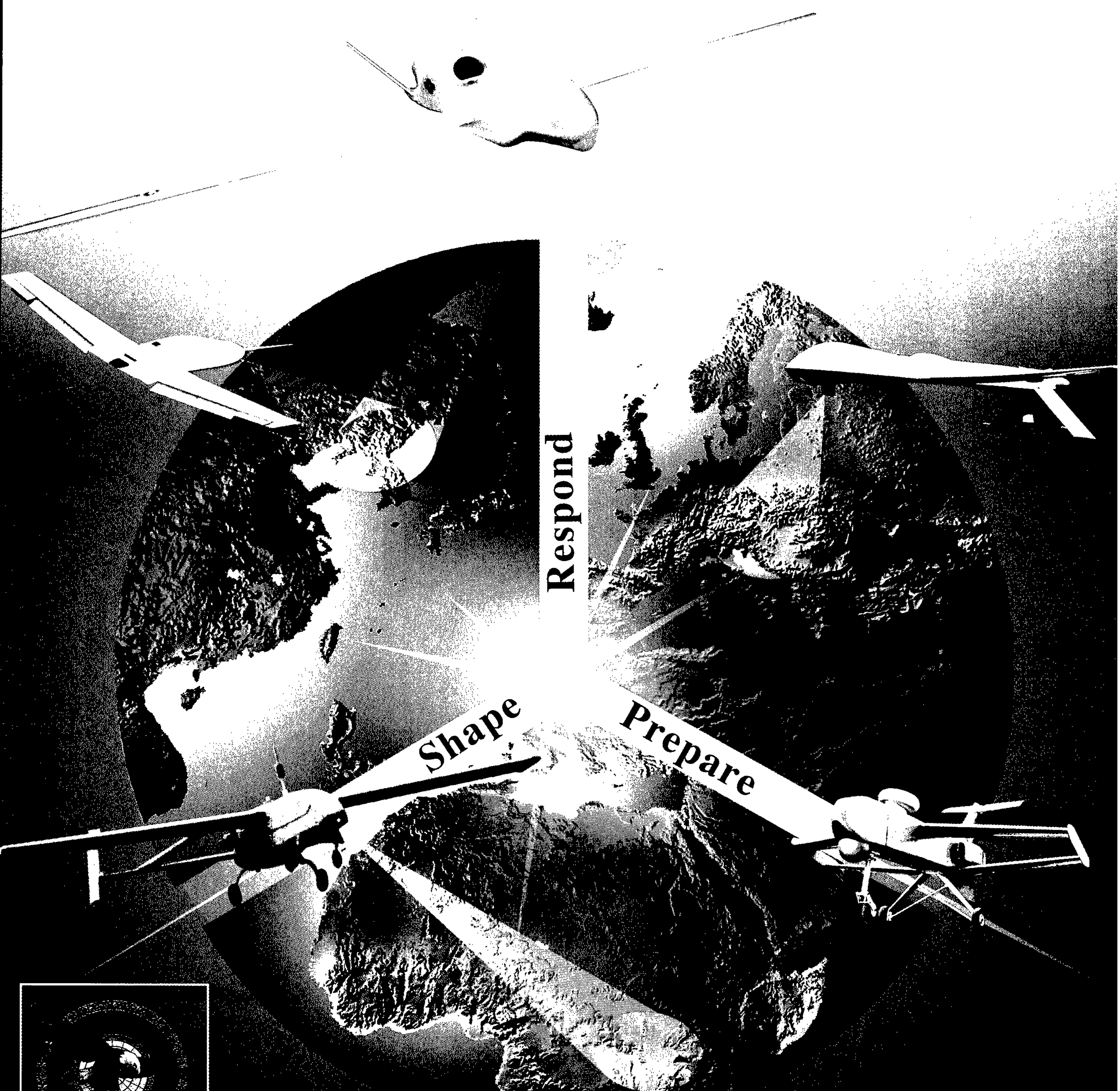
UAV Annual Report FY 1997



Airborne reconnaissance is enduring, but it is not unchanging. As we look to the future, we see our mix of airborne reconnaissance assets evolving in response to new technologies as well as joint strategies, doctrine, and a more diverse threat. In this UAV Annual Report, our third, we see unmanned aerial vehicles playing an ever-increasing role, not only in the intelligence, surveillance and reconnaissance (ISR) world, but in other mission areas as well. The U.S. military faces a challenging future in an era of dynamic change, constrained resources, potential new roles, and rapid technological advancement. These factors require innovative thinking and new ways to shape change. UAVs will help us shape this change. They represent both a revolution in military affairs and a revolution in business affairs.

***Joint Vision 2010 (JV 2010)** is built on the premise that modern and emerging technologies — particularly information-specific advances — should make a new level of joint and coalition capability possible. Underlying these technological innovations is information superiority, the ability to collect, process and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same. We can achieve full spectrum dominance through:*

1. ***Dominant Maneuver;***
2. ***Precision Engagement;***
3. ***Full-Dimensional Protection; and***
4. ***Focused Logistics.***

"There always comes a moment in time when a door opens and lets the future in."

Graham Green

The capacity to dominate any adversary and control any situation in any operation will be the key capability we ask of our armed forces in the 21st century. UAVs will provide a sustained, responsive, accurate picture of the battlefield.

*In addition to JV 2010, our operational concept for the future, the **National Security Strategy for a New Century** stresses the "**imperative of engagement.**" Many aspects of our strategy are focused on **shaping** the international environment to deter or prevent threats. A second element of this integrated approach is the requirement to maintain an ability to **respond** across the full spectrum of potential crises, up to and including fighting and winning major theater wars. Finally, we must **prepare** today to meet the challenges of tomorrow's uncertain future.*

As you can see on the cover of this year's report, we expect to use our growing UAV capability to support our national strategy, to include being "on call" to respond to transnational threats. Our tactical and endurance UAVs continue to make significant progress and will complement both our manned systems and our space sensors. We can take great satisfaction from the following accomplishments:

- Predator, *the Defense Department's first Advanced Concept Technology Demonstration Program (ACTD), was approved for production and a block upgrade program. Our other ACTDs, the* Outrider *Tactical UAV and the* Global Hawk *and* DarkStar *High Altitude Endurance (HAE) UAVs, experienced delays but are on track for 1998.* Outrider *has flown successfully with its new UEL engine.*
- Pioneer *continues its operational service and passed the 15,000 flight-hour mark this past July. Detachments both continue their shipborne deployments and support the test, evaluation and demonstration of UAV subsystems and payloads. Readiness has been increased to about 70 percent.*
- *The Tactical Control System (TCS), which will provide an interoperable system to enable multiple host systems to interface eventually with all UAVs, has been demonstrated successfully. So has* Outrider's *ground station.* Predator's *ground station will be procured in a smaller, repackaged version for easier transport and use in the field.*

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The DARO third annual UAV Annual Report provides an overview of the Defense Department's UAV program activities for fiscal year (FY) 1996. The Defense Airborne Reconnaissance Office (DARO) is chartered to manage the Defense Airborne Reconnaissance Program (DARP) which includes both tactical and endurance UAVs among its component program elements.

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acquisition by both tactical UAVs and Predator. *As for the HAE UAVs,* DarkStar's *electro-optical (EO) and synthetic aperture radar (SAR) sensors and* Global Hawk's *radar sensor have been flown successfully on testbed aircraft.*

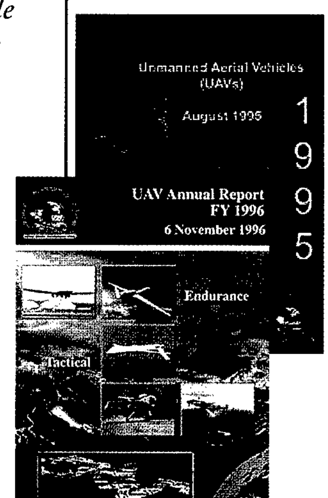
- *The Air Force has activated both its UAV Battlelab (at Eglin AFB, FL) and the 15th Reconnaissance Squadron (RS) (like the 11th RS, near Nellis AFB, NV). The UAV Battlelab, like the other Services' battle labs, is exploring UAV contributions to both Service and joint missions. The 15th RS was established two years early to be fully prepared for* Predator's *fielding in quantity.*
- *The Joint Requirements Oversight Council's UAV Special Studies Group (JROC UAV SSG) has continued its prioritization of payloads by mission, in conjunction with the Services and operational Commanders-in-Chief (CINCs), for* Outrider, Predator, Global Hawk, *and* DarkStar. *This will rationalize UAV payload requirements across systems and missions, as a warfighter's guide for acquisition planning.*
- *The Command, Control, Communications, Computers, and Intelligence, Surveillance and Reconnaissance (C4ISR) Joint Warfighting Capability Assessment (JWCA) process has developed UAV concepts and identified UAV contributions to JV 2010. In further support, the DARO Architecture Development Team (DADT) has developed an Objective Architecture for the year 2010, together with a force migration roadmap and investment strategy to achieve it. Our Communications Systems Analysis provided air and space communications needs to support airborne reconnaissance and complement space-based intelligence systems.*
- *Finally, resolution of several program and management issues with Congress and within the Department strengthened our overall approach to UAV acquisition while reaffirming the importance of a family of UAV capabilities to meet the needs of 21st century warfighters.*

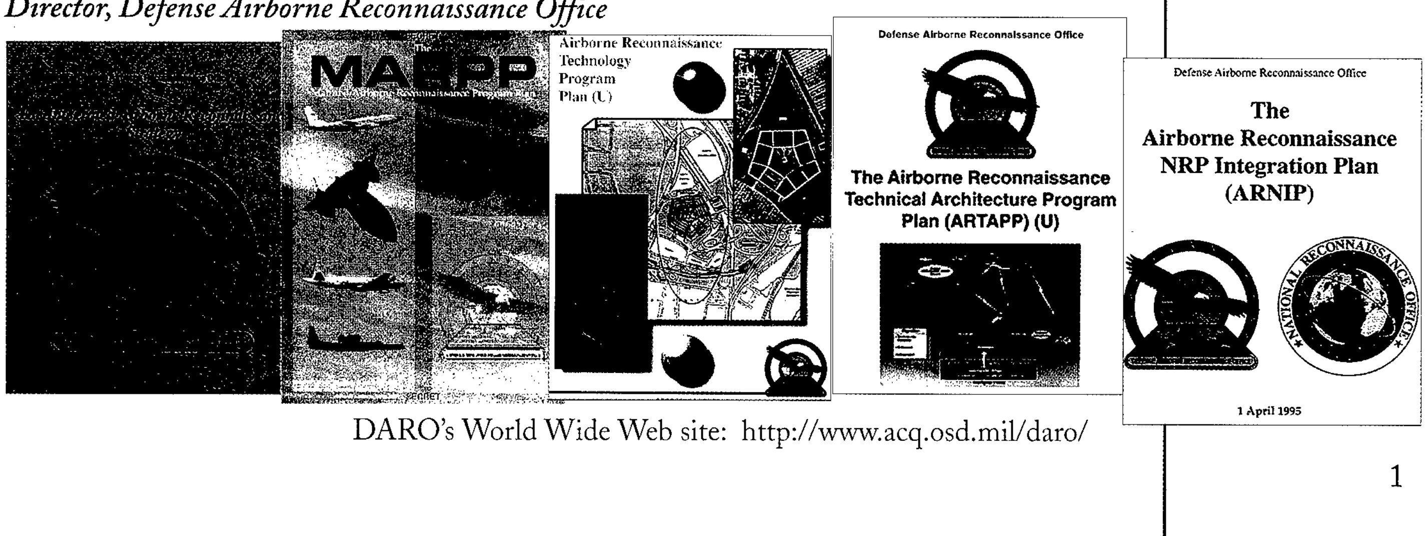
In summary, FY 1997 has been a transition year. The UAV community has persevered both in meeting acquisition challenges and in integrating projected UAV capabilities into military operations wherever useful. Our challenge for the near future will be to prove and build enough UAV systems to meet this expanding demand while ensuring their operational fit into current force structures and C4ISR functions. Working together, we have the opportunity to create a safer, more prosperous tomorrow for ourselves and our allies. I thank you for your continuing support, and look forward to the challenges of 1998.

Maj Gen Kenneth R. Israel, USAF
Director, Defense Airborne Reconnaissance Office

"You can take the example of [retired Chief of Staff] General Fogleman's vision to 'find, fix, target, track and engage anything of significance on the face of the earth' as we enter the next decade ... Some of that you will do from airborne platforms, some of it from space platforms and some of it will migrate from one to the other. Some of it will always be best done with a combination of air and space."

Gen John Jumper, USAF
27 Oct 97
(Nominated for COMUSAFE)





DARO's World Wide Web site: http://www.acq.osd.mil/daro/

UAV Program Resource Summary

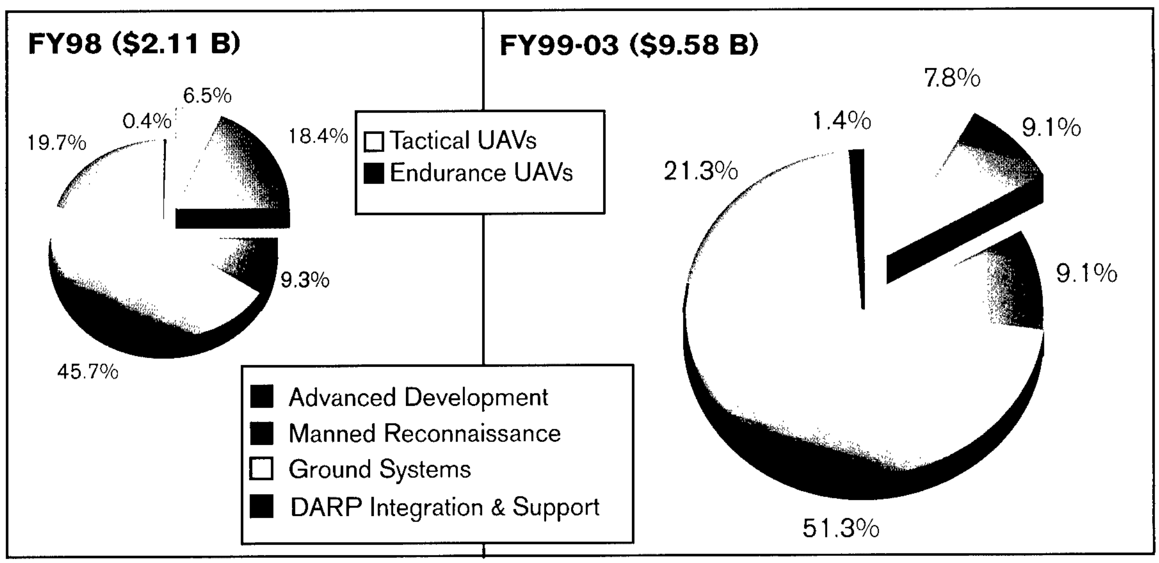
Tactical UAVs

- ❐ ***Pioneer***: Nine systems operational with Navy and Marine Corps. Continual contingency deployments, test support.
- ❐ ***Hunter***: Seven systems acquired. Army is operating one system for CONOPS development and training; other assets support tests and demonstrations.
- ❐ ***Outrider***: Six systems planned for the Tactical UAV (TUAV) ACTD for Army, Marine Corps, and Navy. First flight occurred in Mar 97, followed by subsystem validation.

Endurance UAVs

- ❐ ***Predator***: DoD's first ACTD; 12 systems now in acquisition. Existing assets in operation by the Air Force in Bosnia.
- ❐ ***Global Hawk***: Five UAVs planned for HAE ACTD as a high-altitude, wide-area, long-dwell surveillance platform. Roll-out in Feb 97, taxied in Oct 97.
- ❐ ***DarkStar***: Four UAVs planned for HAE ACTD as a high-altitude stealth UAV for wide-area surveillance of highly defended areas. Redesigned after AV #1 crash in Apr 96; AV #2 plans to taxi in Dec 97.

DARP Resource Allocations

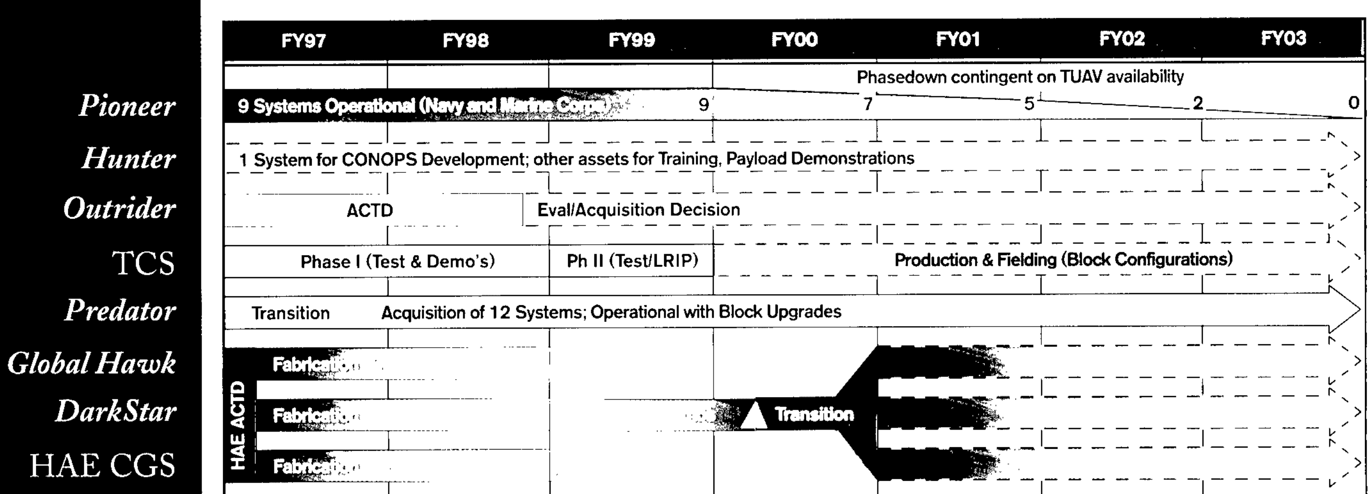


The Defense Airborne Reconnaissance Program (DARP) budgets about $2 billion per year for investment (RDT&E and Procurement).

UAV investment comprises 25% of the FY 1998 DARP budget, and 17% of the Future Years Defense Program (FYDP) in the outyears. (Production resources for *Outrider* and HAE UAVs are projected pending post-ACTD DoD procurement decisions).

Integrated UAV Schedule

Potential UAV and ground station program schedules are projected for the FYDP period.



Congressional Actions

Enactment of the FY 1998 Budget

Several Congressional committees with oversight over airborne reconnaissance addressed many UAV-related issues during the Authorization and Appropriations processes. The approved FY 1998 UAV budgets are tabulated below, with specific issues discussed in the numbered notes that follow.

Program / Item	Request [a]	Approp'n [b]	Remarks [c]	¶
Tactical UAV *(Outrider)*	$ 83.3	$ 45.0	Funding for ACTD without LRIP; funds transferred to Army	1
Common Systems Development (CSD)	4.2	0.0	HFE development funding (for TUAV) eliminated	2
Tactical Control System (TCS)	34.5	42.5	$8.0M added to support TCS for *Predator*	3
Vertical Takeoff and Landing (VTOL)	0.0	8.0	Plus-up to demonstrate advanced VTOL technologies	4
Multifunction Self-Aligned Gate (MSAG)	0.0	4.0	Funded (in the TCS line) to continue MSAG development	
Hunter Operations & Maintenance (O&M)	2.2	12.0	Plus-up to fund operation of existing *Hunter* systems	
Pioneer	4.0	7.0	Plus-up to support UCARS "throughout DoD"	
Pioneer	42.7	42.7	Fully funded	
Predator RDT&E	15.0	15.0	Funds transferred from Defense-wide to Air Force RDT&E	
Predator Procurement (UAVs & spares)	116.5	141.5	Fully funded procurement, plus $25.0M for additional spares	
Global Hawk	96.0	96.0	Fully funded *(Global Hawk* SIGINT not funded)	5
DarkStar	54.6	54.6	Fully funded	6
HAE Common Ground Segment (CGS)	51.1	42.1	$9.0M reduction, but not to be applied to the two HAE CGS	7

[a] President's Budget Request. [b] Appropriations prior to undistributed reductions and other adjustments. [c] All dollars in millions.

Notes on Congressional Program/Budget Actions

1. Provides $45 million for "the continued development, testing and evaluation of *Outrider.*" (Also rescinded $20 million of FY 1997 funding.) The Army Secretary is to provide an acquisition strategy to the Appropriations Committees after user testing and evaluation are complete (see p. 27).
2. CSD not funded for FY 1998. Funding for heavy fuel engine development denied. Other common support programs funded separately: MSAG in the TCS line, and other activities under DARO's Advanced Technologies line.
3. Funds added to the TCS line to procure *Predator* assets for TCS integration.
4. Funds added to continue VTOL UAV demonstrations and to begin an advanced UAV technology program (that should include a stopped-rotor, high-speed, reaction-driven concept) (see p. 11).
5. HAE UAV ACTD platforms were fully funded. A separate initiative to develop a SIGINT payload for *Global Hawk* was denied.
6. Per request, DoD will conduct a study of Moving Target Indication (MTI) on *DarkStar.*
7. A $9 million reduction was directed to other items in the HAE CGS line, as prior-year funds "are available for continued testing" of the HAE CGS itself.

Additional Budget Impacts

An additional, undistributed FY 1998 budget reduction will further affect the numbers above and in the program description pages that follow. Allocations of this reduction are still being determined at press time.

Summary of FY 1998 Budget Actions

While the redirection of the Tactical UAV program line involves both funding and program changes, many of which parallel current DoD determinations, the Congress has continued its overall support for UAVs as systems that will play increasingly significant roles in military operations of the future. Generally sustained funding for FY 1998 programs attests to the Congress's continued interest in, and encouragement of, UAVs' expanding utility in pursuit of our national goals.

Predators Over Bosnia

Deployments to Europe to support joint and combined operations in the Balkans were the major UAV "success story" of last year. This success story continues. *Predator's* second deployment began in March 1996 and, though originally scheduled to end in February 1997, has been extended through February 1998. Meanwhile, *Pioneer's* land-based Bosnia deployment ended in October 1996, while naval deployments continue to the Adriatic and Mediterranean Seas.

Predator System Evolution

The configuration of *Predators* flying over Bosnia includes:

- ❒ EO/IR and synthetic aperture radar (SAR) imagery sensors;
- ❒ C-band and Ku-band SATCOM on-board links (a UHF SATCOM link is being removed); and
- ❒ Ice-mitigation features.

These capabilities reduce, but do not fully correct, *Predator's* vulnerability to in-flight icing. A "weeping wing" de-icing feature, which lightly sprays the front and upper wing surface with antifreeze, will finish testing in December 1997 and become part of the baseline configuration with subsequent retrofit into all existing systems (see p. 31).

Predator's Operational Utility

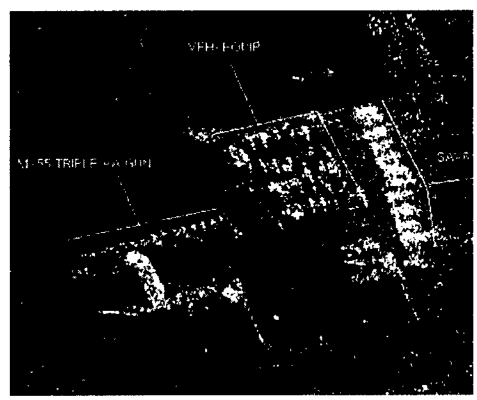
Mission	Objective
Surveillance and Monitoring	Humanitarian Assistance
Target Location	NATO Troop Protection
Reconnaissance	Pre- and Post-Strike Intelligence
Battle Damage Assessment (BDA)	Dayton Peace Accord Enforcement
	Peace-keeping Support

Predator's primary current missions are shown at left. The system generates critical and timely live imagery and imagery-derived intelligence for operational commanders and coalition forces. Support has been provided on a near-daily basis, often when other collection sources were not available. Recent examples of Bosnia imagery are shown below.

Bosnia Imagery

EO

IR



SAR

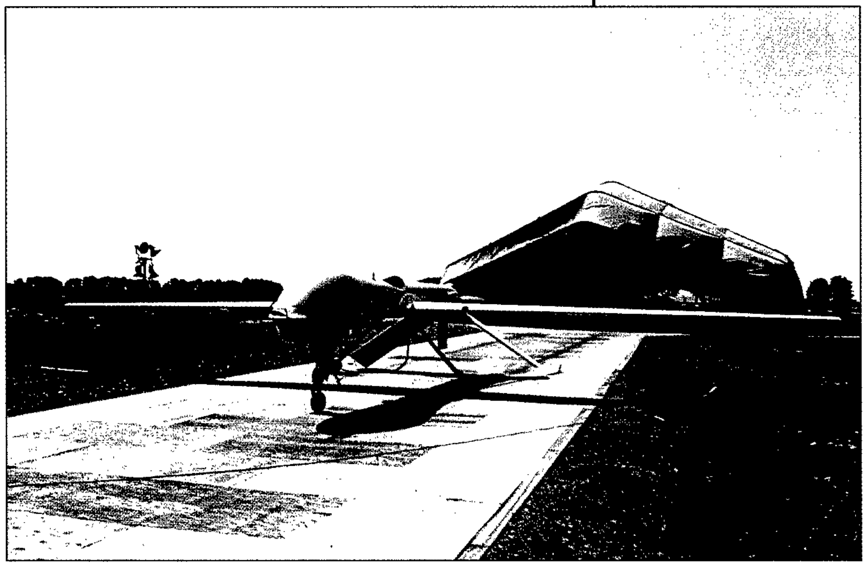
"The guys [at the Combined Air Operations Center] in Vicenza are dependent on UAVs. We need to make them work. We rely on them more than I thought."

Lt Gen Kenneth E. Eickmann, USAF Commander, Aeronautical Systems Center 24 Oct 97

Field Operations

Based at Taszar in Hungary, *Predator* has provided surveillance and reconnaissance support, first for Operation Joint Endeavor as part of NATO's Implementation Force (IFOR), and then for Operation Joint Guard as part of its Stabilization Force (SFOR). Operated by the Air Force Air Combat Command's 11th Reconnaissance Squadron (RS) since September 1996, *Predator* has flown 294 operational missions from March 1996, when Operation Joint Endeavor began, through 30 September 1997. Area and point targets include helicopter staging areas, cantonment areas, mass grave sites, equipment assembly areas, storage sites, and personnel movements (both military and civilian). In the Fall of 1997, *Predator* was assessed as SFOR's best surveillance asset. It provided the following support for SFOR operations and NATO activities:

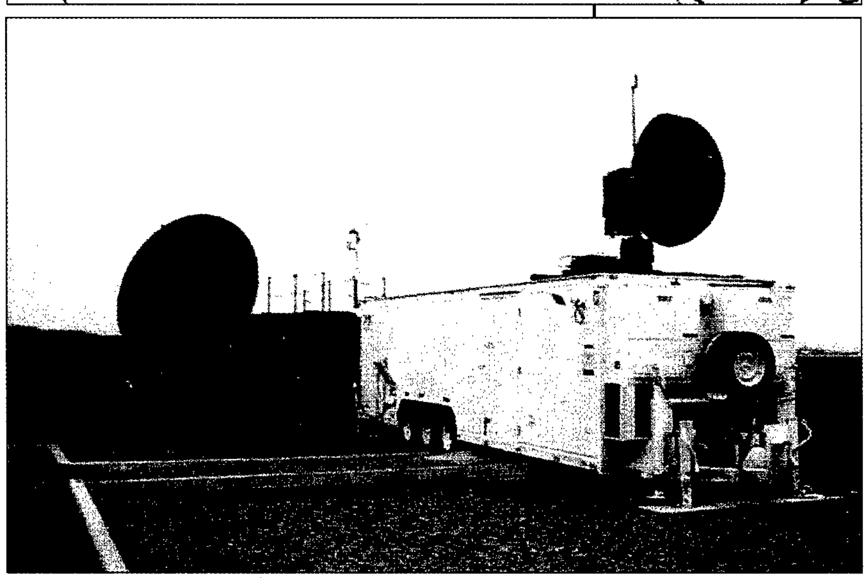
- Surveillance to assist route planning and force security operations, to include the Pope's visit in April;
- Monitoring trouble spots to help provide early warning of crises;
- Monitoring of polling stations and access routes during September's municipal elections;
- Supporting U.S. Secretary of State Madeleine Albright's October visit to Brcko with security assistance, force protection and force monitoring; and
- High-resolution day/night imaging of weapons cantonment areas, to ensure compliance with the Dayton Accords.



A *Predator* taxis from its hangar in Taszar, Hungary

Airspace Management. From the beginning, integration of *Predator* flights into Balkan airspace has employed time and space control procedures to ensure deconfliction with other air traffic. *Predator* is flight-controlled by its Ground Control Station (GCS) along route- and altitude-specific air corridors through international airspace to and from its operating areas over Bosnia. The air vehicle (AV) takes off into Hungarian airspace, traverses Croatian airspace via a narrow corridor, enters Bosnian airspace via a single fixed-time entry and exit point to perform its missions, and reverses the route for recovery. A combination of established procedures, continuing liaison with air traffic control authorities and real-time coordination of changes assures safety while covering the tasked targets.

Dynamic Retasking. The mission continues to evolve and overall capabilities continue to improve. The 72-hour air tasking message (ATM) cycle time required during *Predator's* first deployment (to Gjader, Albania) has been overtaken by "dynamic" or "in-flight retasking," which allows a tactical commander to direct the AV and/or its sensors, by telephone, while watching their down-linked video. Its imagery is disseminated by a Trojan Spirit II terminal through the Joint Broadcast System (JBS) to theater and international command and control (C2) facilities. This provides near-real-time control of the UAV from virtually anywhere.



Predator's Ground Control Station at Taszar, Hungary

Pioneer Operations

Nine *Pioneer* systems are operated by the Navy and Marine Corps. The Navy's five systems are assigned to VC-6, located at Webster Field, St. Inigoes, MD. The Marine Corps' two systems are assigned to VMU-1 and VMU-2, located at the Marine Corps Air-Ground Combat Center (MCAGCC), Twentynine Palms, CA, and Marine Corps Air Station (MCAS) Cherry Point, NC, respectively. Both Services have one or more deployments under way most of the time. The remaining two systems are located at Ft. Huachuca, AZ (see p. 10).

Pioneer continued its ten-year history of mission support in both operational and acquisition arenas. FY 1997 operational activities are tabulated below. They begin with a return from Bosnia and continue with land- and sea-based deployments throughout the year. Meanwhile, several Marine remote receiving station (RRS) teams remained in Bosnia to help with imagery collection, to include monitoring of potential trouble areas during the September 1997 elections. *Pioneer's* system test and payload support activities are detailed on pages 36 and 39.

Pioneer Operational Deployments and Support

May 96 – Present VMU - 2 Bosnia Remote Receiving Station (RRS) support (Three 2-man teams)
Jul 96 – Present VMU-1 Bosnia RRS Support (Four 2-man teams)

Dates	Unit	Deployment	Mission: Support –	Activities / Accomplishments
14 Jun – 29 Oct 96	VMU-1	**First Bosnia land-based deployment** (near Tuzla)	UN IFOR operations with direct intelligence, surveillance, and reconnaissance (ISR)	• Provided **real-time imagery** directly to IFOR units • Used for **dynamic retasking** of units • **Surveillance** of population centers and suspected terrorist training areas, and route **reconnaissance**
24 Jun – 19 Dec 96	VC-6 Det 1	Mediterranean Sea, aboard USS Austin (LPD 4)	Fleet operations: Exercise Dynamic Mix (available for contin-gencies)	• **Real-time reconnaissance/surveillance** of beach for Turkish units and USMC • **Targeting, BDA**. Fully integrated with amphib ops • USMC Cobra crews used *Pioneer* video and pix for **real-time intelligence** on unknown airfield
2 –20 Feb 97	VMU-2	NAS Key West, FL	Joint Task Force (JTF) 6 operations	• Provided surveillance info to Commander JTF 6 for **counter-drug ops**
Feb/Mar Mar/Apr Sep/Oct 97	VC-6 Det Pax	Naval Strike and Air Warfare Center, NAS Fallon, NV	Carrier Air Wing exercises - CVW-1 - CVW-9 - CVW-7	• **Pre- and post-strike reconnaissance** and **BDA**
15 Feb – 9 Mar 97	VMU-1	MCAS Yuma, AZ	Marine Corps Weapons and Tactics Instructor (WTI) course	• Demonstrated direct uplink of live *Pioneer* video to the cockpit of an airborne F/A-18 using Arid Hunter **(= real-time information in the cockpit / RTIC)**
21-25 Apr 12-16 May 20-28 Jun 20-30 Jul 18 Aug – 5 Sep 97	VC-6 Det 2	USS Shreveport (LPD 12) workups	- Training Services - PMINT - COMPTUEX - MEUEX - JTFEX / SOCEX	• JTFEX / SOCEX included support from Aberdeen Proving Ground with a second *Pioneer* system
7 Apr – 23 May 97	VMU-2	MGAGCC, Twenty-nine Palms, CA	Combined Arms Exer-cises (CAX) 5 & 6	• **Close Air Support (CAS)**
6-23 Jun 30 Jun – 14 Jul 97	VMU-1	MGAGCC, Twenty-nine Palms,CA	CAXs 7 & 8	• **CAS**
18 Sep – 21 Oct 97	VC-6 Det 3	USS Denver (LPD 9)	Type Training / COMPTUEX	• Shipboard training and integration

Pioneer's continuing utility is reflected in the fleet's flying time, increased readiness, and decreased accident rate.

Task Force XXI – Advanced Warfighting Experiment

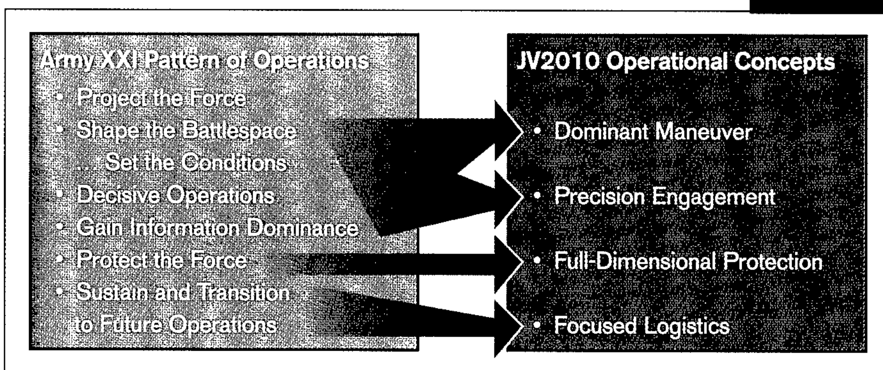
As part of its joint effort to redesign the Army for the 21st century and integrate information technologies in the process, the Army has been conducting a series of digitized Advanced Warfighting Experiments (AWEs) at the National Training Center (NTC) at Fort Irwin, CA. These are designed to develop combat operations for the 21st century. Task Force (TF) XXI, or NTC rotation 97-06, addressed multiple Army objectives that focused on forces, operations, tactics and systems developed around enabling information systems and digital technologies. From 15 through 28 March, the "blue" Experimental Force (EXFOR, the 1st Brigade of the 4th Infantry Division) engaged in force-on-force operations against the NTC's "red" Opposing Force (OPFOR), following several months of prior smaller-unit exercises and training. TF XXI also involved joint participation by Marine Corps, Air Force and Special Operations Forces, which supported the EXFOR.

Among several information-enhancing systems supporting the EXFOR were UAVs:

- Eight *Hunter* air vehicles (AVs), as surrogates for the *Outrider* Tactical UAV; and
- The *Gnat 750* as a surrogate for the *Predator* UAV.

The Army's major combat operational concepts and their linkages to Joint Vision (JV) 2010's concepts are shown to the right.

UAV contributions to the EXFOR's performance are documented below.



UAV Contributions to the TF XXI AWE

The effects of UAVs on the battle were emphasized in testimony by GEN Hartzog, Army TRADOC Commander, before the Senate's AirLand Forces Subcommittee:[1]

> *Unmanned aerial vehicles were one of the big winners at the NTC rotation 97-06. Clearly they are emerging as the next generation of airborne reconnaissance. Technological advances in electronics, materials, propulsion, construction, and communications are bringing about the reality of collection and near- to real-time dissemination of information. The ability of the UAV to penetrate enemy airspace and dwell over and near target areas is essential to Army XXI warfighters and represents a vital link to other reconnaissance vehicles and platforms. The imaging systems of the UAVs allow commanders to detect, identify, and track hostile activity in sufficient time to target with lethal weapons systems or maneuver against or around them, as appropriate, and conduct battle damage assessment. Additionally, the UAV enhances the commander's ability to locate, identify, and track friendly forces to avoid fratricide. In the foreseeable future, UAVs will also give us the capability to detect nuclear, biological, and chemical weapons; see*

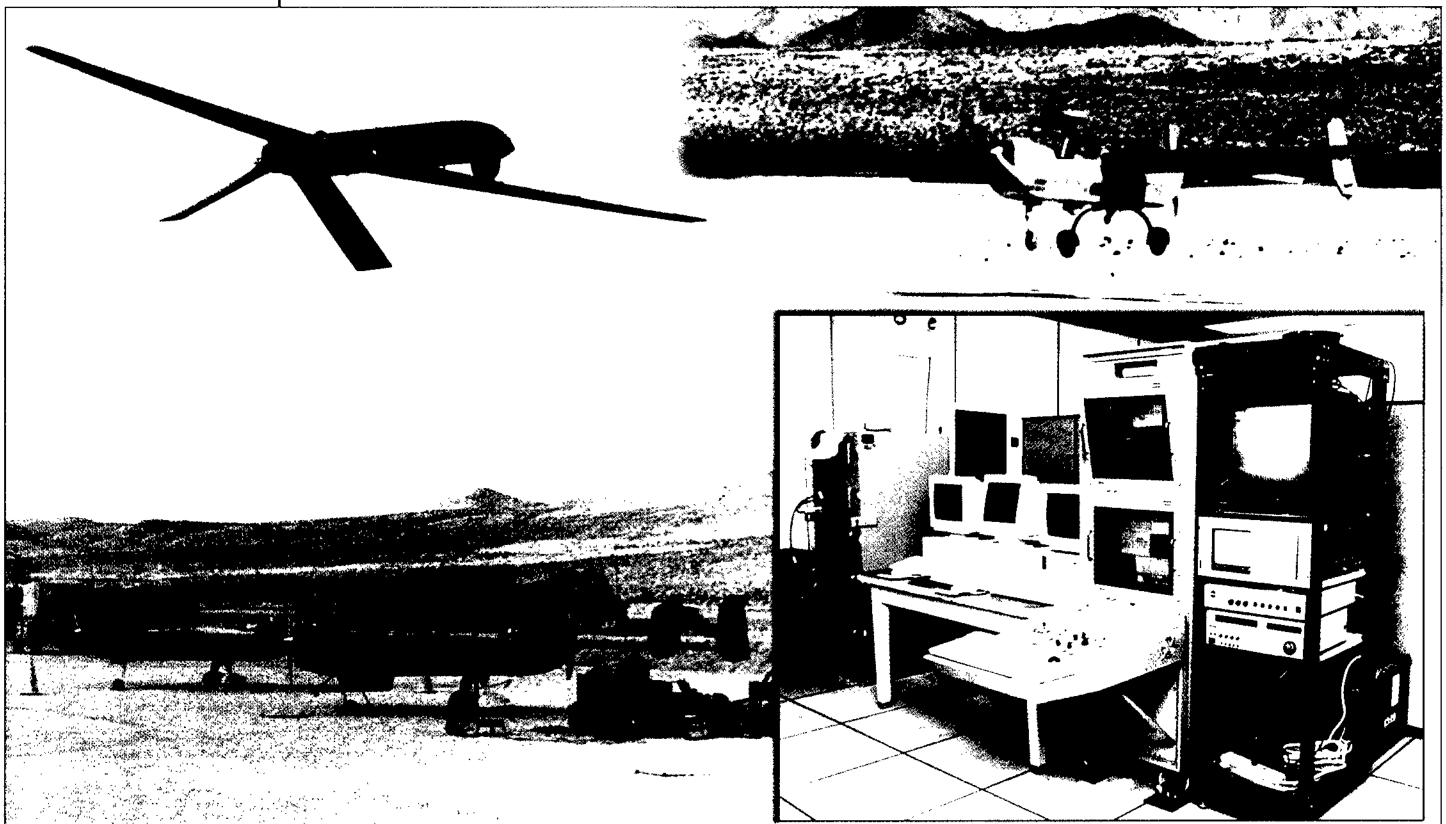
EXFOR soldiers control a tactical UAV

"I will give up a tank battalion for a UAV company."

MG Kern, Commander, 4th Infantry Division, to GEN Reimer, Army Chief of Staff, March 1997

[1] GEN William W. Hartzog, Commanding General, U.S. Army Training and Doctrine Command (TRADOC). Statement before the AirLand Forces Subcommittee, Senate Armed Services Committee, 9 April 1997

"Unmanned aerial vehicles were one of the winners ..."



Hunters, Gnat 750 and TCS supporting EXFOR during TF XXI

into double and triple canopy jungles; and provide low cost and reliable communications and data relay across the battlefield....

Those of us at the NTC noticed that the UAV had an interesting effect on the OPFOR. They spent a lot of time looking for it, and tended to talk about it on the radio as well. That allowed intelligence forces a chance to intercept the conversations and provided much valuable visual and audible data. In very initial reports, the Operational Test and Evaluation Command (OPTEC) notes that the OPFOR reaction to Hunter's presence on the battlefield included movement of vulnerable assets more often, dispersal of equipment over larger areas, maintenance of key assets in no-fire zones, dedication of SA-8s and SA-9s to the UAV fight, delayed movement to defensive positions to the last possible moment, and attempts to continually track the UAV from audio signature.

The Secretary of Defense and other senior military and civilians within the Department of Defense were also favorably impressed with the performance of the unmanned aerial vehicles, calling the UAV the "cream of the crop at the NTC" and "the future of the Army."

Operators and soldiers were enthusiastic about the system as well. The UAV provided a level of intelligence never before available to commanders.

During the exercise, *Hunter* flew 56 sorties for 282 hours in the tactical UAV role, while the *Gnat 750* flew 5 sorties for 23 hours as a medium-altitude endurance (MAE) UAV.

In addition to the UAVs, the Tactical Control System (TCS) also participated in the exercise, as part of its program definition phase. It demonstrated the following:

- Passive receipt of *Gnat 750 (Predator)* and *Hunter* (TUAV) imagery;
- Multiple UAV management; and
- Connectivity to other participating command, control, communications, computers and intelligence (C4I) facilities.

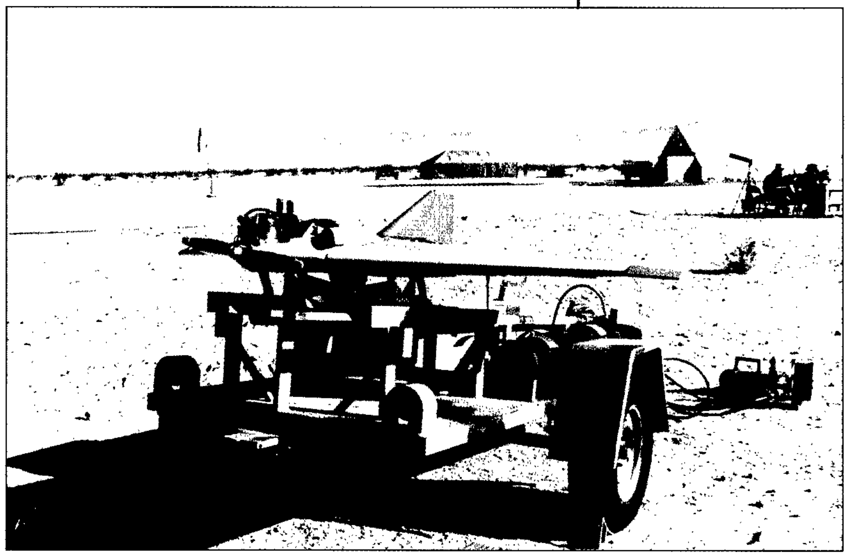
In addition to the Army's appreciation for UAVs' impact on the battlefield, they are increasingly recognizing the need for the fusion of UAV products with other intelligence, surveillance and reconnaissance (ISR) capabilities, and for more training.

Hunter Warrior

The Marine Corps' Warfighting Laboratory conducted the Hunter Warrior AWE at Camp Pendleton, CA, in early March 1997. This exercise, based on concepts from the USMC's "Maneuver from the Sea," demonstrated the ability of a small, highly mobile force to evade and fend off a larger one with the aid of advanced computer and surveillance assets.

The Blue Force's 13 surveillance and sensor systems included the *Exdrone* UAV, or "*Dragon Drone*." An Enhanced Combat Operations Center at Camp Pendleton coordinated the different fire support systems. Blue's tactics were to overwhelm the OPFOR with simulated strikes from long-range precision weapons provided by Navy vessels offshore and other Marine Corps fire support sessions, cued by *Exdrone* and other sensors. The "harassing" effect of multiple sensors caused the OPFOR to experience a "fish-bowl" effect — the feeling of being watched all time.

Exercise results showed that the right equipment and technologies, used well, can greatly help a small expeditionary force to overcome a larger, more heavily armed foe.



Exdrone on its launcher at Hunter Warrior

Ulchi Focus Lens

Ulchi Focus Lens 97, a joint and combined-force command post exercise for defense of South Korea, was conducted in August 1997. Both UAVs and the TCS were simulated by the Multiple UAV Simulation Environment (MUSE) system (see p. 39). MUSE's command and control component, acting as a TCS surrogate, demonstrated control of simulated *Predator, Outrider*, *Hunter* and *Pioneer* UAVs performing surveillance and reconnaissance functions for the friendly force. TCS tasks were those that will be provided when the system is operational, such as air vehicle/payload control and the message/imagery transmission functions that are key to intelligence and target data dissemination.[2]

Other Exercises and Activities

From 28 May to 31 October 1997, the Naval Strike and Air Warfare Center at NAS Fallon, NV, focused on Navy UAV concept of operations (CONOPS) development, using four *Hunter* UAVs (as a "light" system) in a variety of roles and scenarios. A summary of other UAV participation in exercises further indicates their increasing range of mission applications and military utility, as shown in the following table:

Exercise / Activity	UAV Mission / Functions	UAV	Date
Environmental Survey	Artillery encroachment	Pointer	Oct 96
Navaho Nation Building	Natural resource monitoring (three activities)	Pointer	FY97
Survivability Demonstration	Survivability	Pointer	Nov 96
NASA Air Sampling	Air sample collection	Pointer	Feb 97
Hunter Warrior	Reconnaissance, fwd handoff of targets, ground sensor dispensing	Exdrone	Mar 97
DESFIREX	Tactics, techniques, procedures for target location & artillery adjustment	Exdrone	Mar 97
Ranger Battalion Exercise	Artillery adjustment	Pointer	May 97
Airborne Forces Entry Exercise	Operational force support	Pointer	May 97
Roving Sands	Laser designation and range finding	Hunter	May 97
NAS Fallon Training	Laser designation and range finding / personnel recovery	Hunter	Jul 97
Woodland Cougar	Personnel recovery	Exdrone	Aug 97

2 Tactical messages were transmitted to the Automated Deep Operations Coordination System (ADOCS), All-Source Analysis System (ASAS), and Contingency Theater Automated Planning System (CTAPS). UAV imagery was transmitted to the 5D server, Closed Circuit Television (CCTV) and Video Imagery Exploitation Workstation (VIEWS) at exploitation sites in South Korea.

Operations and Training

Joint UAV Training Center (JUAVTC) — Ft. Huachuca, AZ

The JUAVTC houses Delta Company, of the Army's 304th Military Intelligence Battalion (MI Bn). Delta Company conducts both initial and advanced training on the *Hunter* UAV for air vehicle (AV) and payload operators and for electronic and mechanical system maintainers. It graduated 146 students in FY 1997 and projects 198 for FY 1998.

The company's mission also includes:

- Development of UAV doctrine and training materials;
- Preparation of Army personnel for worldwide UAV support; and
- UAV support for Army Force XXI initiatives, AWEs, and system developments.

Special activities for this past year included:

- A long-range mission test, where a locally launched *Hunter* was transferred to a deployed Forward Control Element and usable imagery transmitted well beyond normal operating ranges;
- Incorporation of UAV relay flight training into its training syllabus; and
- Targeting and BDA support for a Navy Tomahawk test launch.

NAMTRAGRUDET — Ft. Huachuca, AZ

A detachment of the Naval Aviation Maintenance and Training Group (NAMTRAGRU), formerly the Defense UAV Training Center (DUTC), operates two *Pioneer* systems. As a tenant in the JUAVTC facility, it coordinates closely with the 304th MI Bn. It provides operator and maintainer training on the *Pioneer* UAV for both Navy and Marine Corps personnel. During FY 1997, the group trained 138 students and plans to train 109 during FY 1998. Its graduates then go on to staff the Navy's and Marine Corps' operational *Pioneer* units (VC-6, and VMU-1 and VMU-2, respectively; see p. 6).

11th RS:

- Activated August 1995 at Nellis AFB, NV.
- Assumed operational control of *Predator* assets in Bosnia at Taszar, Hungary, 2 September 1996.

11th Reconnaissance Squadron (RS) — Indian Springs, NV

The 11th RS operates *Predator* for the Air Force at Indian Springs Auxiliary Air Field, NV (near Nellis AFB). Its activities are divided between *Predator* support for NATO forces in Bosnia (see pp. 4-5) and training *Predator* operators and crews. Both activities are being pursued with limited assets, pending receipt of production and additional refurbished assets. Accomplishments to date reflect the current maintenance robustness of the *Predator* system.

Predators have flown more than 330 missions and 2,600 hours in general reconnaissance support for Bosnia operations since the 11th RS assumed operational control of *Predator* assets (see *UAV Annual Report: FY 1996*, pp. 7 and 9). The deployed unit currently has two AVs and one GCS; a third AV was lost in August 1997 while on short final approach following an in-flight emergency. However, by controlling that *Predator's* recovery to avoid populated areas and any collateral damage, its operator demonstrated that UAVs could be flown as safely in restricted airspace as manned aircraft under equivalent conditions.

The 11th operates two more AVs and one GCS at Indian Springs, where it has graduated six payload instructors and 12 AV pilots to date, with 6 more pilots graduating in December 1997.

15th RS Standup Ceremony

15th Reconnaissance Squadron (RS) — Indian Springs, NV

This new squadron was activated on 1 August 1997. It joined the 11th RS, near Nellis AFB, NV, as the Air Force's second *Predator* operating unit, though it will not receive actual systems until a year later. The Air Force made it operational 26 months earlier than expected to ensure the Service's readiness to operate UAV assets as soon as they are available.

Special Activities

Exdrone to Dragron Drone: From Exercise to Operations

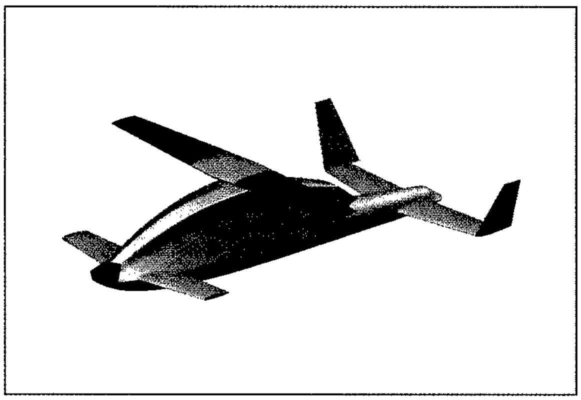
Following *Exdrone's* strong performance during the Hunter Warrior AWE in March 1997, the Marine Corps plans to make it seaworthy for operational experimentation aboard amphibious ships. The Marine Corps Warfighting Lab is upgrading ten *Exdrones* as *Dragon Drones* with a shipboard launch and recovery capability, heavy fuel engine, forward-looking infrared (FLIR) sensor and differential global positioning system (GPS). The Marines plan to deploy them on at least one ship for demonstration purposes, beginning in FY 1998.

VTOL Evaluation

The Congress provided $15 million in FY 1997 to fund a vertical takeoff and landing (VTOL) UAV demonstration. The DoD determined that this activity required a competitive procurement and the Navy released a Broad Area Announcement (BAA) in October 1997. It plans to award one or more VTOL UAV contracts in December 1997 for demonstration(s) during FY 1998. The Navy's objectives are to evaluate current VTOL UAV maturity and technology risks associated with a system development for naval operations.

Advanced VTOL Technologies Program

For FY 1998, the Congress has funded the start of a demonstration program for future VTOL UAV technologies, to include a stopped-rotor high-speed VTOL platform concept. This concept is embodied in a canard rotor/wing (CRW) design called *Dragonfly.* The CRW will perform as a helicopter for takeoff and landing and as a fixed-wing aircraft (using its stopped rotor as a wing) for high-speed cruise. *Dragonfly's* potentially high-payoff technology may be applied to future manned as well as unmanned systems.



PEO(CU) Move to Patuxent River, MD

The Navy's Program Executive Office for Cruise Missiles and Joint UAVs (PEO(CU)), moved from Arlington, VA, to NAS Patuxent River, MD, in June 1997. Its UAV Joint Program Office (JPO) completed its transition in July. The overall move, which included the Naval Air Systems Command (NAVAIR), was made in compliance with the Base Realignment and Closure (BRAC) decisions of 1993. PEO(CU) maintains a liaison office in Arlington, VA.

TMD Hunter/Killer Experiment

Army Special Operations Forces, using S-TEC *Sentries* and AeroVironment *Pointers,* are planning to participate in Ballistic Missile Defense Organization (BMDO) -sponsored exercises during the winter of 1997 – 98. The UAVs will be the "hunters" in active Theater Missile Defense (TMD) hunter/killer teams attempting to find and destroy tactical ballistic missile launchers before they can launch their missiles.

Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS)

The Office of Naval Research (ONR) established CIRPAS in Spring 1996 to provide UAV flight services to RDT&E customers in their development, testing and evaluation of UAV technologies, payloads, and system capabilities. Assets include the *Pelican* (a Cessna 337 derivative) and *Aerosonde* low-altitude and the *Altus* high-altitude AVs, satellite communications, a GCS, air traffic control relay radios, and selected monitoring and payload packages. Assets may be leased as turn-key UAV operations to support research. CIRPAS is associated with the Naval Postgraduate School in Monterey, CA, and will operate from Ft. Hunter-Liggett from 1998 on.

Concepts

Battle Labs

DARO sponsored the first joint-Service UAV Battle Lab Symposium 16 – 17 April 1997. Representatives attended from five of the Army's Battle Labs, the Naval Strike and Air Warfare Center (NSAWC), the Marine Corps Warfighting Lab, and the Air Force's UAV Battlelab; also from the Services' UAV staff and program offices, and from other labs.

The Services' battle labs exist to infuse operational thinking into critical mission areas. By focusing on innovative concepts supported by technology, they hope to generate imaginative and "out-of-the-box" ideas from the field — from the warfighter — and conduct operationally oriented experiments and demonstrations. Current UAV activities among the battle labs are summarized below.

Army Battle Labs. The Army established its battle lab organization in 1992. While the Battle Command Battle Lab (Ft. Huachuca, AZ), or BCBL(H), had the lead on UAV activities in the Task Force XXI operational exercise (see pp. 7-8), no one Army lab is in the lead for UAVs. Specific activities include examining UAV operations:

- Integrated with manned aircraft;
- As rear-area security platforms;
- Supporting deep strike operations and their battle damage assessment (BDA);
- As airborne communications nodes;
- As platforms for chemical/biological and mine detectors.

Additional BCBL(H) initiatives involve:

- The Combat Synthetic Test and Training Assessment Range (CSTTAR), which tests video and data transfer between the MUSE and the Army's All-Source Analysis System's Remote Work Station (ASAS RWS); and
- An experimentation program to examine and assess UAV tactics, techniques and procedures (TTP) used by Army tactical units.

Navy. The NSAWC, at NAS Fallon, NV, is developing Navy UAV CONOPS (see p. 9).

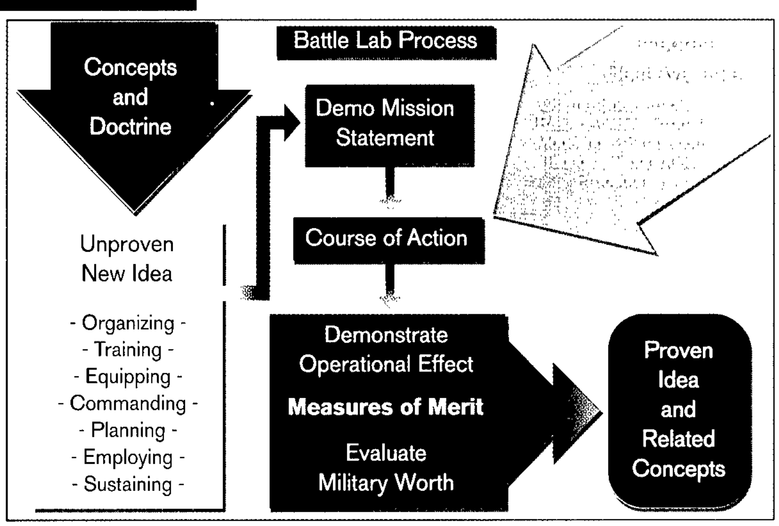
Marine Corps Warfighting Lab. The Commandant established this lab at Quantico, VA, in 1996. Its UAV initiatives have focused on tactical support for lower-echelon units via small UAVs, such as the *Dragon Drone*, *Pointer* and *Sender* UAVs. In addition, the Marines are examining UAV dispensing of leaflets and non-lethal agents, such as pepper spray and tear gas.

Air Force Battle Labs. The Air Force has established six battle labs this past year. The UAV Battlelab, which stood up officially on 1 July 1997 at Eglin AFB, FL, already has three initiatives underway:

- Demonstrating UAVs as long-endurance threat warning and location platforms to support Suppression of Enemy Air Defenses (SEAD) operations;
- Flying a QF-4 drone with a Traffic Alert and Collision Avoidance System (TCAS) aboard, to show UAV compatibility with airspace safety requirements; and
- Exploring UAV support for "bare base" security operations, where quick perimeter surveillance and threat detection could be vital precursors to more permanent measures.

This third initiative is a cooperative effort with the Force Protection Battle Lab, which stood up in June 1997 at Lackland AFB, TX. This battle lab's two-year UAV security demonstration project is looking more broadly at local area surveillance, detection of explosives, and lethal and nonlethal ways of neutralizing threats.

DARO plans to convene another joint-Service UAV Battle Lab Symposium in 1998, again to share ideas and foster synergies from complementary activities.



Evolving Missions and Concepts

Small Scale Contingencies (SSC)

SSCs are assuming a larger role in the DoD's planning and preparations. In addition to surveillance and reconnaissance functions for traditional military operations, these functions are being applied to broader contingency scenarios where U.S. and allied forces may not be directly involved. These operations include:

- Humanitarian Relief Operations (HUMROs);
- Noncombatant Evacuation Operations (NEOs); and
- Peacekeeping Operations (PKOs).

As evidenced by successful Bosnia operations, during the past two years, UAVs are able to overfly trouble areas well beyond friendly force lines. This makes them natural assets for the cost-effective, nonthreatening performance of extended surveillance and reconnaissance functions.

In June 1997, the Commander-in-Chief of European Command (CINCEUR) requested options for a small-footprint, easily deployable UAV to support Joint Task Forces (JTFs) conducting NEOs and HUMROs, using a sub-Saharan Africa scenario. In response, DARO prepared information on numerous DoD- and industry-developed tactical UAVs for EUCOM staff review. In November 1997, DARO and EUCOM representatives are visiting a number of industry contractors to gather additional information for further assessment.

Real-Time Information to the Cockpit (RTIC)

RTIC, or sensor-to-shooter linkage, has been a crucial need since allied forces' largely unsuccessful efforts to target mobile missile launchers during the Persian Gulf War of 1991. The Air Force has conducted several demonstrations using high-data-rate (HDR) satellite communication channels to link intelligence and tactical assets in the targeting of mobile, fleeting targets.

Meanwhile, during VMU-1's *Pioneer* deployment to support a Marine Corps Weapons Tactics Instruction (WTI) exercise at Yuma, AZ during February and March 1997, VMU-1 demonstrated the direct uplink of live *Pioneer* video to the cockpit of an airborne F/A-18. As such demonstrations increase in number and mission application, UAV roles and capabilities will also expand.

Boost-Phase Intercept (BPI)

The Persian Gulf War of 1991 reinforced the value of active theater missile defense (TMD). Post-war analysis further indicated the benefits of intercepting enemy missiles early, namely in their boost phase where their launch plume would make them easier to see. Now, a May 1997 report by the Ballistic Missile Defense Organization (BMDO) looks at the feasibility of using armed UAVs as TMD platforms.

Among other options, the study examined modified *Global Hawk* configurations as interceptor missile platforms. By replacing its reconnaissance sensors with an infrared search and track sensor and mounting missiles under the wings, analysts traded some of *Global Hawk's* fuel and endurance for the extra weight of the weapons packages. The resulting systems could still provide significant on-station endurance, depending on range from base. Challenges include assuring separation of interceptor from UAV at launch, continued target tracking and interceptor guidance during the engagement, and how much self-protection the UAV might need. Costs for an optimized *Global Hawk* were projected in the \$1- to \$2-billion range for a 24- to 74-UAV force size (plus ground stations), which would compare favorably with any similarly proposed capability to date.

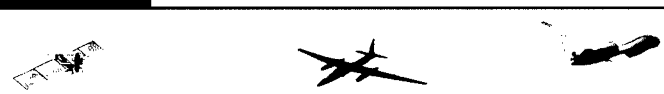
This and other studies of armed UAVs, such as the Uninhabited Combat Air Vehicle (UCAV), are beyond DARO's responsibility for nonlethal UAVs. However, the clear advantages of UAVs as multipurpose platforms are becoming increasingly well-recognized. Broader mission applications for *Global Hawk* and other developmental UAVs are fueling an expanding demand.

An Expanding Analytic Base

DARO's Airborne ISR Analysis Program

In late-FY 1996, DARO formed the DARO Architecture Development Team (DADT) to develop an Objective Architecture and investment strategies for the migration of "stovepiped" airborne reconnaissance assets by the year 2010. During the past year, the DADT has participated in or reviewed ISR studies DoD-wide and performed its own architectural and force mix study, with investment strategy, culminating in a draft system roadmap to achieve its goal.

To reach this point, the DADT established a broad-based modeling, simulation and analysis (MS&A) capability, which used both tools and an iterative methodology to provide insights for the initial development of the DARO's 2010 force structure projection. Selected systems, combined as architectures for given scenarios and yielding information products, result in recommended force mixes that are subjected to cost/benefit analyses that generate program requirements for future systems. More robust MS&A capabilities will strengthen and extend initial insights, thus enabling more comprehensive system, force mix and architectural performance assessment. Continued iteration and refinement of tools and techniques will eventually support both in-depth and quick-turn systems analyses.



National / Commercial + Manned + Unmanned
Reconnaissance Systems

Rationalize Requirements

Airborne Force Mix Option Studies

Agency	Study	
DARO	DADT	DARO Architecture Development Team
NRO/DARO	APEX	Airborne Performance Evaluation Exercise
OSD	QDR	OSD Quadrennial Defense Review [a]
ASD(C3I)	CMA	C4ISR Mission Assessment
USA	ATIS	Army Tactical Imagery Study
JWCA/J-2		Recce 2010
NRO	SAMS	Spacecraft-Aircraft Mix Study
NIMA	AIMS	Aircraft Imagery Mix Study
DIA	MAIS	Military Assessment of Imagery Systems
NSA/OSD	SMS	SIGINT Mix Study
Services		Wargames [b]
DSC	Study II	C4ISR Impacts on Strike Warfare

[a] No force mix specified [b] Tend to support UAVs across the board

DoD Force Mix Studies

Most current DoD studies of aircraft, UAV and/or satellite force trades are "single-INT." They do not show the benefits of multi-sensor cross-cueing, or of future advanced processing and communications technologies. In addition, many of the studies' results are not easily comparable. Nevertheless, several provide at least first-order support for DARO projections, which envision a UAV force mix of about 240 tactical UAVs, 48 Predators, and 35 HAE UAVs.

DSC Studies. Two studies by DoD's C4ISR Decision Support Center (DSC) specifically involve UAVs. "Study II" addressed C4ISR impacts on Strike Warfare, to include the use of UAVs in densely defended areas for the Suppression of Enemy Air Defenses (SEAD) mission. "Study III" addressed Communications UAVs (CUAVs), projecting *Predator* and *Global Hawk* with communications packages operating with or in place of other surface- and space-based communications systems. It concluded that:

- By augmenting other links, CUAVs could improve theater and tactical communications, especially for mobile or isolated users; but —
- CUAVs could not replace satellite communications for strategic (inter-theater) scenarios with high-capacity long-haul traffic.

Recommendations included acceleration of "proof-of-concept" activities and demonstrations, and development of an unmanned airborne communications node (see p. 42) and comprehensive communications architecture.

AAN Wargames. The "Army After Next" (AAN) project conducts broad studies of future warfare, to include projecting an advanced-technology family of UAVs. In its January 1997 strategic war game set in 2020, for example, Red attacked Blue's space systems all-out. Blue offset their loss by using other assets, including high-altitude UAVs, to maintain tactical knowledge dominance by helping to net the distribution of vital information.

DARO's Objective Architecture and 2010 Force Structure Projection

DARO has recently developed the DoD's first fully integrated airborne reconnaissance architecture to achieve the goal of Information Superiority, which underpins the operational concepts of JV 2010.[3] This architectural framework presents a vision of the entire *Global ISR Enterprise* to support our National Military Strategy, namely to fight and win two nearly simultaneous military theaters of war (MTWs), as well as to support peacetime engagement, deterrence, and conflict prevention. The DARO architecture envisions a complementary, balanced mix of airborne and overhead ISR assets. Its attributes are shown in the table above-right.

Key Attributes of the DARO's Objective Architecture
• Ubiquitous internetting, "network-centric" concept of operations
• Leveraging of commercial and coalition information products and services
• Rapid reconfiguration of operating domains
• Low "cost of entry" (i.e., rapid injection of new capabilities)
• Real-time delivery of information to the warfighter
• Collaborative planning (vice requests for information)
• Warfighter becomes the system "front end" and analyst of choice
• Enterprise-based, market-driven customer service operations

UAV Types. The projected force mix that supports the DARO's airborne reconnaissance architecture comprises five types of UAV for 2010:

- ❒ Multi- or single-INT HAE UAV (based on *Global Hawk);*
- ❒ HAE Airborne Communications Node;
- ❒ *DarkStar* low-observable HAE UAV;
- ❒ *Predator* (with enhancements); and
- ❒ Tactical UAV in large numbers.

Force Migration. With the evolutionary acquisition of technology-enabled and operationally demonstrated capabilities, DARO projects a gradual migration towards UAV dominance in airborne ISR:

- ❒ HAE UAVs to initially augment and eventually replace manned platforms in high-altitude, long-range/endurance, all-weather sensor ISR operations:
  - HAE UAVs (with IMINT and SIGINT) for standoff missions (to replace the U-2);
  - *DarkStar* for penetration missions into heavily defended areas;
- ❒ *Predator* to be produced and enhanced to augment manned systems for medium-altitude missions;
- ❒ Tactical UAVs to augment low- and medium-altitude tactical platforms; and
- ❒ Both *Predator* and *Outrider* to be replaced by updated versions as early as 2010.

General Migration Trends. As selected manned platforms are also improved (or replaced by a single airframe to reduce logistics costs), the overall manned-unmanned airborne reconnaissance force inventory is actually increased to meet the projected two-MTW demands on ISR in the 21st century. Beyond 2010, further incremental replacements or new developments may be fielded, to include a reconnaissance variant of, or pod for, an uninhabited combat air vehicle (UCAV) in the post-2015 time frame.

In addition, information networks, communications links and surface C4I systems also need to migrate — to the future Distributed Reconnaissance Infrastructure (DRI) part of the Global ISR Enterprise to keep pace with today's explosive growth in information generation. Adoption of improved communications technology will pace the migration from current "stovepipes" to an integrated information architecture responsive to the needs of the warfighter. Today's collection of single-INT, Service-specific ground/surface systems connected mostly by point-to-point links will successively lead to:

- ❒ Multi-INT interoperable systems with distributed workgroups collaborating through network interconnections;
- ❒ The addition of software applications that extend Processing, Exploitation and Dissemination System (PEDS) capabilities into non-DARP systems; and
- ❒ Ultimately, fully networked operations supporting "network-centric" warfare.

With their flexible payloads and links, UAVs will be an integral part of this architecture.

[3] Joint Vision 2010: Full spectrum dominance, via —
- Dominant Maneuver
- Precision Engagement
- Full-Dimensional Protection
- Focused Logistics

UAVs and the Acquisition Environment

Acquisition reform and streamlining have been underway for several years. Advanced Concept Technology Demonstrations (ACTDs) are designed to get mature technologies into the hands of users for early evaluation of military utility — before subscribing to a full-scale acquisition program. Essentially, contractors demonstrate and support come-as-you-are systems to combined operator-developer evaluation teams during a two-to-four-year program period (vice the normal ten-year-plus duration of a normal acquisition program). ACTD systems were to include non-developmental item (NDI) and commercial or government off-the-shelf (COTS/GOTS) components where practical.

ACTD OUTCOMES

1. If User Not Prepared to Acquire – Options:	2. If User Wants – One or a few:	3. If User Wants – In Quantity:
a. Terminate (not cost-effective) b. Place "on the shelf" (time not right) c. Develop further (good idea; improve it)	• Fix demonstrator to be operationally suitable; replicate as required	• Enter acquisition process at the appropriate stage

Depending on the operational assessment, one of three ACTD outcomes is envisaged (at left).

DARP UAVs

Predator, DoD's first ACTD and first to transition to a formal acquisition process, fit outcome #3. DoD's other three UAV acquisition programs are also ACTDs:[4]

- *Global Hawk* and *DarkStar* are the two air vehicle components of the High Altitude Endurance (HAE) UAV ACTD, managed by the Defense Advanced Research Projects Agency (DARPA); and
- *Outrider* is the air vehicle in the Tactical UAV (TUAV) ACTD, managed by the Navy's Program Executive Officer for Cruise Missiles and UAVs (PEO(CU)).

An ACTD IS:

- A way to get technology into the hands of operators early, for operational evaluation

An ACTD Is NOT:

- A means of by-passing necessary acquisition processes as a shortcut to deployment

ACTD Lessons Learned

Lessons learned from *Predator* (and other ACTD) experiences are being applied to the ACTD process in general. As noted in last year's report:

> ... the *Predator* ACTD had no projected procurement budget: at its outset (January 1994), nobody knew how well it would perform. Further, while ACTD unit costs may be low (often representing off-the-shelf [OTS] components), militarizing some capabilities and realizing logistics support needs both increase program acquisition costs. For example, while an ACTD *Predator* demo system cost about $15 million, a combat-ready production system (with configuration changes, added payload and link subsystems, and full integrated logistics support [ILS] provisions) requires about twice that sum.
>
> By comparison, the TUAV ACTD includes funding provisions for transition plus significant out-year procurement funds. Eight IPTs [Integrated Product Teams] are active to assure integrated system development. Thus, rather than committing prematurely to a production program before the ACTD results are known, early planning and an LRIP option will optimize the ACTD-to-formal acquisition transition process if the ACTD is deemed successful.

With another year's experience, during which *Predator* completed its transition to formal acquisition and the TUAV ACTD completed its first year, these initial findings have been reinforced. For example, we have learned that DoD must plan for post-ACTD procurement and support well before a complete assessment of military worth — otherwise the process loses time while acquisition prerequisites are "backed" into place. This is not equivalent to a pre-commitment to proceed; instead, it involves the concurrent completion of key program/budget and operational preparations for acquisition. Our goal has been to reduce unnecessary cost-of-ownership burdens — up front in the development and evaluation periods.

Predator

Specific success factors included:

- The importance of technical maturity in avoiding "surprises";
- A single, highly qualified program manager for the duration of the ACTD;

[4] *Pioneer* is an operational system now fully funded by the Navy, and *Hunter* is being used for concept development by the Army and other Services.

- An early opportunity to demonstrate military worth before requirements "grew" too far.

Predator's value in support of Bosnia operations, while still in ACTD status, is well-known. This, in turn, provided an "umbrella" under which operational shortcomings or needs could be identified and resolved. Two additional lessons were derived from this experience:

- The need for timely development and coordination of airspace management practices (both at home and abroad); and
- The importance of logistics, both as an underlay for a successful ACTD and in assuring fielded system suitability.

Outrider

By comparison, the TUAV ACTD *(Outrider)* evolved from an already-planned acquisition program, the Maneuver UAV. It faced the challenge of meeting both Army and maritime requirements with one air vehicle while meeting strict production unit cost thresholds. Also, it was perceived as an "off-the-shelf" system, both to enable early fielding and to meet cost limits. Thus, when significant engineering was required to meet range, engine and shipboard suitability goals, the program fell several months behind schedule. Since that time, a dozen successful flights have both validated its key subsystems and identified capabilities that were "too hard" to attain in a timely manner. For example, a gasoline engine has replaced the heavy fuel engine (HFE) option for the balance of the ACTD, with further HFE development to be consolidated in a separate effort.

HAE UAVs

In contrast, both *Global Hawk* and *DarkStar* were envisioned from the start as needing significant development to work as systems. On the other hand, the operational capabilities projected for each vehicle offered such operational benefits that, if the ACTD approach could enable an early assessment of their military worth, higher risks were well warranted. During this past year, both programs experienced delays for technical problems, but the year delay for each program will still enable their operational evaluation several years earlier than a traditional acquisition program.

A more general set of ACTD lessons learned is listed below.[5]

[5] See also RAND study MR-899-OSD, *The Predator ACTD: A Case Study for Transition Planning to the Formal Acquisition Process*, to be published Fall 1997.

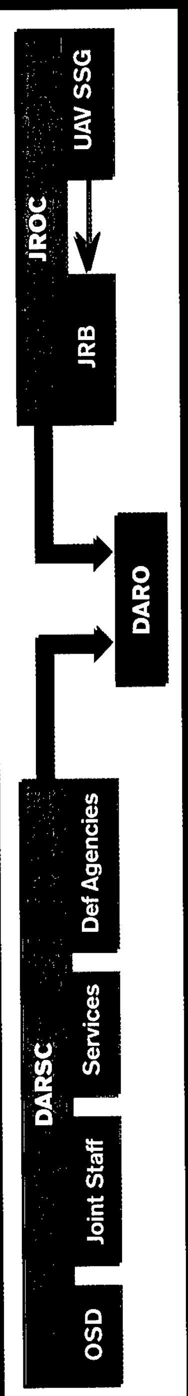
ACTD Issues	Needed to optimize ACTD organization, scope, and conduct:
Choice of demo and operational mgrs	The right people with the right organization relationships, working well together (as in the *Predator* ACTD)
Government program office	Small, effective organization of veteran experts; MOAs to gain outside support
Program control measures	Flexibility and creativity; informal communications; few CDRLs (but enough for supportability planning)
Choice of lead-Service	Lead Service chosen early — to take full part in the ACTD, help evaluate military utility
Declaration of military utility	DoD-level policy and process to guide this evaluation
Funding stability	With tight schedule / high tempo, funding stability throughout the ACTD
Personnel requirements	Personnel skills and training established early (along with Lead Service)
Operational test agency (OTA)	Early involvement (especially by Lead Service OTA); ops / contingency testing is highly beneficial for all

Transition Issues	Completed by end-ACTD to facilitate transition to full acquisition: [a]
Supportability	Key logistics planning as basis for production system design, O&S processes (for residual + production systems), and LCC determination. Involve maintainers early
Producibility	Assurance that post-ACTD design can be produced to desired quantity, rate, and unit cost
Program oversight	Continued OSD mentoring to assure appropriate management organization, sustain user interest / priority
Funding / affordability	Early LCC estimate as input to ACTD decision, to avoid surprises, and to support PPBS wedge for timely acquisition
ORD	Draft to guide military utility evaluation and quantify performance, design, and 'ility goals for transition / acquisition. (A CONOPS is necessary, but not sufficient; the rigor of the ORD process is necessary to define and trade requirements)
Test planning	Initial DT&E plan, plus documented feedback from ACTD assessments

[a] **Note:** *Additional ACTD resources may be needed to support these activities, under the aegis of a Transition IPT.*

UAV Management and Oversight

Several DoD organizations have played continuing roles in the oversight and guidance of UAV capabilities, acquisition, operation, force mix and resource allocations during FY 1997.



Defense Airborne Reconnaissance Office (DARO)

DARO is in its fifth year as DoD's single focal point for improvement of airborne reconnaissance capabilities, reporting to the Under Secretary of Defense for Acquisition and Technology (USD(A&T)). DARO has OSD-level oversight responsibility for airborne reconnaissance architecture determination and systems interface requirements. Accordingly, it develops and coordinates policies and standards to ensure system interoperability, performs system-level trades to support architectural migration and acquisition decisions, and provides planning and resource guidance for the DoD Components' acquisition programs. These programs constitute the Defense Airborne Reconnaissance Program (DARP), and are funded through Defense-wide and DoD Component budget accounts. They encompass manned and unmanned aerial vehicles, sensors and links, their ground stations, and modification activities.

Defense Airborne Reconnaissance Steering Committee (DARSC)

The DARSC is the DoD-wide corporate body that provides executive-level oversight and guidance to the DARO. It is chaired by the USD(A&T); vice chair is the Vice Chairman of the Joint Chiefs of Staff (VCJCS). It meets as necessary to resolve major airborne reconnaissance issues.

Joint Requirements Oversight Council (JROC) and JROC Review Board (JRB)

The JROC reviews operational requirements representing the interests of the operational or warfighting community and its commanders-in-chief (CINCs). The JROC's Chairman is the VCJCS and the JRB is its staff-level review and coordination body. During FY 1996, the JROC issued ten memoranda (JROCMs) addressing UAV priorities and key issues, and providing its assessments and recommendations. Its FY 1997 JROCMs are summarized below.

JROCM-	Summary
159-96 23 Oct 96 **UAV TCS Key Performance Parameters (KPPs)**	**Threshold** – Support mission planning and execution, and data dissemination for TUAV and MAE UAV – Interoperable with select C4I systems (per Joint Technical Architecture) – Simultaneous flight and payload control of ≥ 2 AVs, BLOS, using 1 TCS – Interoperable with different UAVs and payloads across 5 levels of interaction **Objective** – And support data collection from HAE UAV – Same – Same – And multiple platforms/ payloads simultaneously
173-96 12 Nov 96 **Updated UAV Priorities**	**#1: Tactical UAV** – Remains JROC's highest priority; also, maintain Pioneer as "bridge" and accelerate TCS development to parallel Outrider's and also support Predator **#2: Predator** – Transition/fielding to meet the MAE requirement; 16 systems required to meet all needs **#3: HAE UAVs** – With Air Force as lead Service, and CGS as HAE UAV ground station
007-97 13 Jan 97 **Predator's KPPs**	**KPP** • Mobility • Presence (from FLOT to rear of 2d echelon • Search, detect, recognize tactical targets • GCS receive / process / disseminate **Threshold** – Components via C-130 – Continuous 24-hr intelligence (with on-station relief) – EO, IR, SAR sensors at 30,000 ft slant range – From a single AV **Objective** – ≤ 2 C-141 loads – (Same) – At 60,000 ft slant range – From multiple AVs
011-97 3 Feb 97 **UAV TCS ORD**	**UAV TCS ORD** General description of operational capability; threat; shortcomings of existing systems; capabilities required (system performance, logistics and readiness, other characteristicss); program support; force structure; and schedule considerations

UAV Special Studies Group (SSG)

The JROC established the UAV SSG as its staff-level advisory and action organization for the review of UAV issues. Specific SSG responsibilities include the assessment and evaluation of mission needs and joint UAV requirements and issues, to include Operational Requirements Documents (ORDs), interoperability issues, and programmatic aspects such as performance, cost and schedule status. During FY 1997, the UAV SSG developed and coordinated the UAV mission/payload priority guidance with the Services and CINCs and briefed the JRB, as documented on p. 38.

UAV Program Overview

Predator

The most significant programmatic action of FY 1997 was *Predator's* transition to production within the formal acquisition process. Thirteen months of Integrated Product Team (IPT)-managed post-ACTD transition activities and program/budget trade-offs culminated in Defense Acquisition Board (DAB) approval on 8 August 1997. *Predator* is now an ACAT II program under Air Force milestone review authority. Both ACTD-residual assets (like those operating over Bosnia) and new production systems will be progressively block-upgraded to the required operational configuration.

Outrider

Secondly, the *Outrider* program made sufficient progress during the second half of FY 1997 to justify continuation of its Tactical UAV (TUAV) ACTD and funding for FY 1998. After four months' delay of its first flight to accommodate redesign or reintegration of certain commercial off-the-shelf (COTS) components, as well as resizing the airframe itself to sustain system performance, both the air vehicle and subsystems and the ground control station (GCS) were validated in a succession of flights throughout the summer of 1997. An optimized gasoline engine has been integrated and is in flight test.

HAE

Thirdly, while neither HAE UAV flew in FY 1997, both UAVs' subsystems and sensors were demonstrated successfully. *Global Hawk* taxied for the first time in October 1997, and *DarkStar* AV #2, with redesigned nosewheel and flight control subsystems, plans to taxi in December. Both UAVs are poised to fly during 2Q/FY 1998.

Pioneer

Meanwhile, *Pioneers* operated by both Navy and Marine Corps units demonstrated improved readiness as the result of increased funding for attrition AVs and spares since FY 1995. From beginning to end of FY 1997, Pioneer's readiness grew from 60% to 70%, and its accident rate dropped dramatically from 19 Class A and B mishaps[6] during FY 1996 to 6 mishaps during FY 1997. *Pioneer* passed the 15,000 flight hour mark in July 1997.

Hunter

Finally, the few *Hunters* flying exercise and training support demonstrated current system reliability and sustainability well beyond requirements, thereby validating system and management improvements undertaken before the program's production contract was allowed to expire in early 1996. The small *Hunter* fleet passed 6,600 flight hours in September 1997. Its annual mishap rate has improved from 5.0 per 1,000 flight hours to 0.5 — an order-of-magnitude improvement.

Program	Acq'n Mgr	FY96 Status	FY97 Programmatic Action:
Pioneer	Navy: PEO(CU)	Fielded system	Service life extended through FY03
Hunter	Navy: PEO(CU)	Limited ops/storage	Sustaining 1 system for CONOPS & ops support, plus assets for training
Outrider	Navy: PEO(CU)	ACTD program	ACTD continuing
Predator	Navy: PEO(CU)	Post-ACTD transition	Transitioned to formal acquisition: approved for full production phase
Global Hawk	DARPA	ACTD program	ACTD continuing
DarkStar	DARPA	ACTD program	ACTD continuing

Other key activities within the TUAV program included:

- Establishment of a Heavy Fuel Engine (HFE) program as a development consolidated under the Deputy Under Secretary of Defense (Advanced Technology) (DUSD(AT));
- Successive demonstrations of the Tactical Control System (TCS) to receive sensor data from other UAVs; and
- Contract awards to the *Predator* and *Outrider* primes for TCS integration.

[6] Class A: > $1M loss

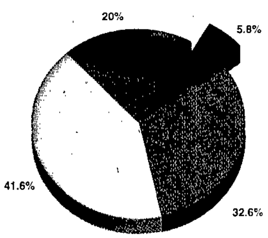
Class B: $200K – $1M

Tactical UAVs

To support: Army battalions, brigades, and light divisions; Marine regiments; and deployed Navy units – Near-real-time reconnaissance, surveillance and target acquisition (RSTA), and battle damage assessment (BDA)

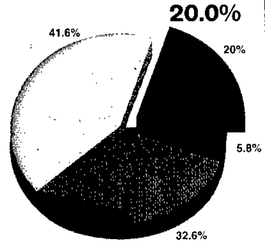
SHARE OF FY 1997 DARP UAV INVESTMENT ($434M)

5.8%



Pioneer

20.0%



TUAV

Pioneer & Hunter

Funding	*Pioneer*	*Hunter*[a]
– FY97	$25.0M	($17.4M)
– FY98	$42.7M	($16.2M)

[a]Army O&M

Program Requirements/Objectives

- Operate up to 15,000 ft and at ranges ≥ 100 nm
- *Pioneer*: Interim EO/IR IMINT for tactical commanders. Operations to be extended until TUAV is fielded
- *Hunter*: Developed to meet Short Range Requirement for tactical commanders. Now limited fielding to support operations, concept development and follow-on training at Ft. Hood, TX, and initial training at Ft. Huachuca, AZ

Acquisition Strategy

- *Pioneer*: Contractor: Pioneer UAV, Inc. Sustain nine systems (with attrition AVs and spares); sustain force through FY03, or until TUAV is fielded in quantity. Acquiring 20 new Versatron 12DS EO/IR payloads
- *Hunter*: Contractor: TRW. Seven systems acquired: One operational at Ft. Hood, with additional assets at Ft. Huachuca; remaining assets in storage. O&S focus on reliability improvements and demonstration

Major Accomplishments

- *Pioneer*: Successful tests of COBRA payload (Nov 96), UCARS ashore (Nov/Dec 96) and at sea (Jan 97), and MIAG (Jul 97). Deployments in Med (VC-6 Det 1 on USS Austin), and to support exercises at NAS Fallon, NV, Yuma, AZ, and others. Passed 15,000 flight hours in Jul 97
- *Hunter*: Provided: key support to Army's Task Force XXI (Mar 97) and to multiple exercises at Ft. Hood; CONOPS development and payload demos at NAS Fallon. Year's performance and reliability far exceeded requirements. Passed 6,600 flight hours in Sep 97

Outrider (TUAV)

Funding	*Outrider*[b]	Other TUAV[c]
– FY97	$46.0M	$19.7M
– FY98	$45.0M	$12.0M

[b]Pending FY98 rescission [c]CSD, TCS, and VTOL

Program Requirements/Objectives

- **Cost:** $350,000 @ 33rd AV, $300,000 @ 100th AV, with sensor
- Operate at 200 km range, up to 4 hrs on station
- Compliance w/JII (now DII/COE) standards
- Demonstrate military utility for reconnaissance and surveillance, tactical situational awareness, gun fire support, BDA

Acquisition Strategy

- Contractor: Alliant Techsystems
- 24-month ACTD: 6 systems and support (now 4). Focus on system integration, shipboard & interoperability demos, exercise support, and logistics definition
- 18-month LRIP option: 6 systems and support (cancelled for FY98). Continued integration, testing, exercise support, and logistics development
- Acquisition strategy under review

Major Accomplishments

- Modified AV design to meet evolved requirements
- Flight #1: 7 Mar 97; 9 flights through 30 Sep; 17 flights through 16 Nov 97
- Completed four USD(A&T) Program Reviews (Feb, Apr, Jun, and Nov 97)
- GCS demonstrated at Pentagon and elsewhere, Jun 97. Transported to Ft. Hood, TX, in Sep for continuing operational demonstrations and evaluation
- Successfully flight-tested key AV subsystems, 13-foot wing; flown with new engine

AV	Air Vehicle
COBRA	Coastal Battlefield Reconnaissance and Analysis
COE	Common Operating Environment
CONOPS	Concept of Operations
CSD	Common Systems Environment
DII	Defense Information Infrastructure
EO/IR	Electro-optical/ Infrared
GCS	Ground Control Station
IMINT	Imagery Intelligence
JII	Joint Integration Interface
LPD	Landing Platform Dock
LRIP	Low-rate Initial Production
MIAG	Modular Integrated Avionics Group
O&S	Operations and Support
TCS	Tactical Control System
TUAV	Tactical Unmanned Aerial Vehicle
VTOL	Vertical Takeoff and Landing
UCARS	UAV Common Automated Recovery System

Endurance UAVs

To support: Joint Task Force Commanders and Theater/National C2 nodes; goal of sensor-to-shooter interface – Long-range, long-dwell, near-real-time theater/tactical intelligence via deep penetration/wide-area surveillance

PREDATOR

Funding[d]	*Predator*
– FY97	$141.5M[e]
– FY98	$195.0M

[d]Includes Service funding [e]Includes UCARS integr'n

Program Requirements/Objectives

- Long-range/dwell, near-real-time tactical intelligence, RSTA, and BDA
- Operate ≥ 15,000 ft and at 400 nm radius
- EO/IR and high-resolution SAR for IMINT

Acquisition Strategy

- **ACTD:** Contractor: General Atomics – Aeronautical Systems, Inc. 30-month ACTD completed Jun 96. Followed by IPT transition planning to enter formal acquisition process
- **Production**: Contractor: General Atomics. Acquire a total of 12 systems, including residual ACTD assets. Develop baseline configuration and Block I upgrades, and procure/retrofit to Block I configuration. ACAT II program; Air Force has milestone decision authority

Major Accomplishments

- Initial phase of de-icing tests completed Apr 97
- During post-ACTD transition: JROC approved KPPs and ORD (3 Jul 97); SAF/AQ approved SAMP (21 Jul) and APB (7 Aug); 20-year LCC completed
- At 8 Aug 97 DAB, USD(A&T) approved entry into formal acquisition process as a production program
- Has flown more than 3,700 hours on Bosnia deployments

HAE UAVs

Funding	*Global Hawk*	*DarkStar*	HAE CGS
– FY97	$67.8M	$55.1M	$57.8M
– FY98	$96.0M	$54.6M	$42.1M

Program Requirements/Objectives

- Military utility w/UFP $10M (FY94 $), AVs #11–20 (average)
- RSTA w/high-altitude, long-range/dwell and wide-area surveillance
- *Global Hawk*: 20 hrs at 65,000 ft and 3,000-nm radius
- *DarkStar*: 8 hrs at 50,000 ft and 500-nm radius

Acquisition Strategy

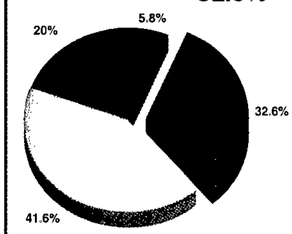
- **ACTD**: Two HAE AVs with CGS to explore military utility and roles/capabilities (USACOM as lead-CINC). DARPA used Other Agreements Authority to streamline contracting and conduct tech demos
- *Global Hawk*: Competitive award to Teledyne Ryan
- *DarkStar*: Sole-source development by Lockheed Martin and Boeing
- **Demo Eval**: Demo military utility (FY 1999-2000)
- **Production**: Decision in FY 2001 (post-ACTD)

Major Accomplishments

- *Global Hawk*: Rollout 20 Feb 97. INS flight tests (on King Air) in Jul 97; SAR flight tests (on A-3) in Oct. Moved to Edwards FTC, CA, in Aug; taxi tests in Oct. Flight #1 expected 2Q/FY98
- *DarkStar*: EO sensor flight tests (on C-130) May 97. Moved to NASA Dryden FTC in Oct 97; taxi tests in Dec. AV-2 flight #1 expected 2Q/FY98
- **HAE CGS**: LRE moved to Edwards FTC in Sep 97. MCE moved to TRA facility in Oct. Preparing for flight operations

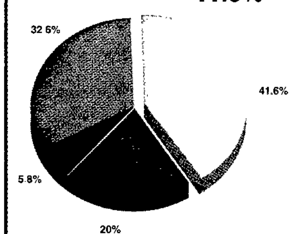
SHARE OF FY 1997 DARP UAV INVESTMENT ($434M)

32.6%



Predator

41.6%



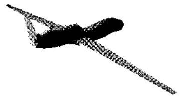
HAE UAVs

ACAT	Acquisition Category
AEW	Airborne Early Warning
APB	Acquisition Program Baseline
BDA	Battle Damage Assessment
C2	Command and Control
CGS	Common Ground Segment
DAB	Defense Acquisition Board
DPE	Data Processing Element
FTC	Flight Test Center
HAE	High Altitude Endurance
INS	Inertial Navigation System
JROC	Joint Requirements Oversight Council
KPP	Key Performance Parameter
LCC	Life-Cycle Costs
LRE	Launch and Recovery Element
MCE	Mission Control Element
ORD	Operational Requirements Document
RCS	Radar Cross-Section
RSTA	Reconnaissance, Surveillance and Target Acquisition
SAMP	Single Acquisition Management Plan
TRA	Teledyne Ryan Aeronautical
UFP	Unit Flyaway Price

	CHARACTERISTICS	Pioneer	Hunter	Tactical UAV Outrider
Operational	**ALTITUDE: Maximum** (km, *ft*)	4.6 km *15,000 ft*	4.6 km *15,000 ft*	4.6 km *15,000 ft*
	Operating (km, *ft*)	≤4.6 km *≤15,000 ft*	≤4.6 km *≤15,000 ft*	1.5 km *5,000 ft*
	ENDURANCE (Max): (hrs)	5 hrs	11.6 hrs	3.6/2.0 hrs @100/200 km
	RADIUS OF ACTION: (km, *nm*)	185 km *100 nm*	267 km *144 nm*	≥200 km *≥108 nm*
	SPEED: Maximum (km/hr, *kts*)	204 km/hr *110 kts*	196 km/hr *106 kts*	>222 km/hr *>120 kts*
	Cruise (km/hr, *kts*)	120 km/hr *65 kts*	>165 km/hr *>89 kts*	167 km/hr *90 kts*
	Loiter (km/hr, *kts*)	120 km/hr *65 kts*	<165 km/hr *<89 kts*	111-139 km/hr *60-75 kts*
	CLIMB RATE (Max): (m/min, *fpm*)	244 m/min *800 fpm*	232 m/min *761 fpm*	488 m/min *1,600 fpm*
	DEPLOYMENT NEEDS:* *Depends on equipage & duration	Multiple* C-130, C-141, C-17 or C-5 sorties Ship: LPD	Multiple* C-130, C-141, C-17 or C-5 sorties	C-130 (drive on/drive off) Ship: LHA/LHD (roll on/roll off)
Air Vehicle	**PROPULSION: Engine(s)**	One Recip; 2 cylinders, 2-stroke	Two Recips: 4-stroke	One Rotary; pusher prop
	– Maker	– Sachs & Fichtel SF 2-350	– Moto Guzzi (Props: 1 pusher/1 puller)	– UEL AR801R
	– Rating	19.4 kw *26 hp*	44.7 kw *60 hp*	37.3 kw *50 hp*
	– Fuel	AVGAS (100 octane)	MOGAS (87 octane)	AVGAS/MOGAS
	– Capacity (L, *gal*)	42/44.6 L *11/12 gal*	189 L *50 gal*	53 L *14 gal*
	WEIGHT: Empty (kg, *lb*)	125/138 kg *276/304 lb*	544 kg *1,200 lb*	195-208 kg *432-458 lb*
	Fuel Weight (kg, *lb*)	30/ 32 kg *66/ 70 lb*	136 kg *300 lb*	36 kg *80 lb*
	Payload (kg, *lb*)	34/ 34 kg *75/ 75 lb*	91 kg *200 lb*	27 kg *60 lb*
	Max Takeoff (kg, *lb*)	195/205 kg *430/ 452 lb*	726 kg *1,600 lb*	>227 kg *>500 lb*
	DIMENSIONS: Wingspan (m, *ft*)	5.2 m *17.0 ft*	8.9 m *29.2 ft*	4.0 m *13.0 ft*
	Length (m, *ft*)	4.3 m *14.0 ft*	7.0 m *23.0 ft*	3.3 m *10.9 ft*
	Height (m, *ft*)	1.0 m *3.3 ft*	1.7 m *5.4 ft*	1.5 m *5.0 ft*
	AVIONICS: Transponder	Mode IIIC IFF	Mode IIIC IFF	Mode IIIC IFF
	Navigation	GPS	GPS	GPS and INS
	LAUNCH & RECOVERY: Land:	RATO, Rail; Runway, (A-Gear)	RATO, Unimproved Runway (200 m)	Unimproved Runway
	Ship:	RATO; Deck w/Net		Large-deck Amphibious Ship
	GUIDANCE & CONTROL:	Remote Control/Preprogrammed	Remote Control/Preprogrammed	Prepgmd/Remote Con/Autopilot/Autolan(
Payload & Links	**SENSOR(S):**	EO or IR (EO and IR with new sensor)	EO and IR	EO and IR (SAR growth)
	DATA LINK(S): Type	Uplink: C-band LOS & UHF LOS Downlink: C-band LOS	C-band LOS	C-band LOS (Digital growth)
	Bandwidth: (Hz)	C-band LOS: 10 Mhz UHF: 600 MHz	20 MHz	20 MHz
	Data Rate: – Analog (Hz) **– Digital** (bps)	C-band LOS: 10 MHz UHF: 7.317 kbps	20 MHz	20 MHz with embedded 19.2 kbps C2 and telemetry data stream
	C2 LINK(S):	Through Data Links	Through Data Link	Through Data Link
System & Support	**SYSTEM COMPOSITION:**	5 AVs, 9 payloads (5 day cameras, 4 FLIRs), 1 GCS, 1 PCS, 1–4 RRSs, 1 TML (USMC units only)	8 AVs, 8 MOSPs, 4 ADRs, 4 RVTs, 3 GCSs/MPSs, 2 GDTs, 1 LRS, 1 MMF	4 AVs, GCSs, GDTs, 1 RVT, 1 MMF (per 3 systems), LRE, GSE
	PRIME/KEY CONTRACTOR(S):	Pioneer UAV, Inc.	TRW Avionics & Surveillance Group	Alliant Techsystems
	MAJOR SUBCONTRACTORS: – Air Vehicle, Propulsion, Avionics, Payloads, Information Processing, Communications, Ground and Support Systems	AAI Corp; Computer Instrument Corp; General Svcs Engrg; Humphrey; Israel Aircraft Industries (IAI); Sachs; Trimble Navigation	Alaska Ind.; Burtek; Consolidated Ind.; Fiber Com; Gichner; IAI/Malat; IAI/Elta; IAI/Malat/Tamam; ITT/Cannon; Lopardo: Mechtronics; Moto Guzzi	BMS; Cirrus Design; CDL; FLIR Systems IAI Tamam; IntegriNautics; Lockheed Martin; Mission Technologies; Phototelesis TI; Rockwell Collins; SwRi; Stratos Group UAV Engines Ltd

Column Notes: *AV weights: Option 2 / Option 2+*

Tier II, MAE UAV ***Predator***	Tier II+, CONV HAE UAV ***Global Hawk***	Tier III–, LO HAE UAV ***DarkStar***
7.6 km *25,000 ft* 4.6 km *15,000 ft*	19.8 km *65,000 ft* 15.2–19.8 km *50,000–65,000 ft*	15.2 km *50,000 ft* 15.2 km *50,000 ft*
≈35 hrs	38 hrs (20 hrs at 5,556 km/*3,000 nm*)	12 hrs (8 at 926 km/*500 nm**)
740 km *400 nm*	5,556 km *3,000 nm*	>926 km *>500 nm*
204-215 km/hr *110-115 kts* 120-130 km/hr *65- 70 kts* 111-120 km/hr *60- 65 kts*	>639 km/hr *>345 kts* 639 km/hr *345 kts* 630 km/hr *340 kts*	556 km/hr *300 kts* 556 km/hr *300 kts* 241 km/hr *130 kts*
137 m/min *450 fpm* (912 eng) 244 m/min *800 fpm* (914 eng)	1,036 m/min *3,400 fpm*	610 m/min *2,000 fpm*
Multiple* C-130 sorties	AV: Self-Deployable GS: Multiple* C-141, C-17 or C-5 sorties	Multiple* C-141, C-17 or C-5 sorties
One Fuel-Injected Recip; 4-stroke - Rotax 912/Rotax 914 63.4/75.8 kw *85/105 hp* AVGAS (100 Octane) 409 L *108 gal*	One Turbofan – Allison AE3007H 32 kN *7,050 lb static thrust* Heavy Fuel (JP-8) 8,176 L *2,160 gal*	One Turbofan – Williams FJ 44-1A 8.45 kN *1,900 lb static thrust* Heavy Fuel (JP-8) 1,575 L *416 gal*
544 kg *1,200 lb* 300 kg *660 lb* 204 kg *450 lb* 1,134 kg *2,500 lb*	4,055 kg *8,940 lb* 6,668 kg *14,700 lb* 889 kg *1,960 lb* 11,612 kg *25,600 lb*	1,978 kg *4,360 lb* 1,470 kg *3,240 lb* 454 kg *1,000 lb* 3,901 kg *8,600 lb*
14.8 m *48.7 ft* 8.1 m *26.7 ft* 2.2 m *7.3 ft*	35.4 m *116.2 ft* 13.5 m *44.4 ft* 4.6 m *15.2 ft*	21.0 m *69 ft* 4.6 m *15 ft* 1.5 m *5 ft*
Mode IIIC IFF GPS and INS	Mode I / II / IIIC / IV IFF GPS and INS	Mode IIIC IFF GPS and INS
Runway (760 m/*2,500 ft*)	Runway (1,524 m/*5,000 ft*)	Runway (<1,219 m/*<4,000 ft*)
Prepgmd/Remote Control/Autonomous	Preprogrammed/Autonomous	Preprogrammed/Autonomous
EO, IR, and SAR	EO, IR, and SAR	EO or SAR
C-band LOS; (growth to Ku-band TCDL); Ku-band SATCOM	UHF LOS and SATCOM; X-band CDL LOS; Ku-band SATCOM	UHF LOS and SATCOM; X-band CDL LOS; Ku-band SATCOM
C-band LOS: 20 MHz Ku-band SATCOM: RL/CL: 5/9 MHz	UHF LOS/SATCOM: 25/25 kHz X-CDL LOS: RL/CL: 137/64 MHz Ku-SATCOM: RL/CL: 3-69/0.26 MHz	UHF LOS/SATCOM: 9.6/25 kHz DAMA X-CDL LOS: RL/CL: 137/64 MHz Ku-SATCOM: RL/CL: 26/(N/A) MHz
C-band LOS: 20 MHz Ku-band SATCOM: RL: 1.544 Mbps CL: 64 kpbs	UHF LOS/SATCOM: 9.6/9.6 kbps X-CDL LOS: RL: 137 Mbps (48 used) CL: 200 kbps Ku-SATCOM: RL: 1.5-48 Mbps CL: 200 kbps	UHF LOS/SATCOM: 4.8/1.2 & 2.4 kbps* X-CDL LOS: RL: 137 Mbps (84 used) CL: 200 kbps Ku-SATCOM: RL: 1.54 Mbps CL: (N/A)
Through Data Links	Through Data Links	Through UHF LOS, UHF SATCOM, or CDL LOS
4 AVs, 1 GCS, 1 Trojan Spirit II Dissemination System, GSE	AVs (TBD); HAE CGS	AVs (TBD); HAE CGS
General Atomics-Aeronautical Systems	Teledyne Ryan Aeronautical	Lockheed Martin Skunk Works/ Boeing Military Aircraft Division
Boeing Defense & Space (DEMPC); Litton (INS/GPS); L3 Com (Ku-band SATCOM); Magnavox/ Carlyle Gp; Northrop Grumman (SAR); Rotax Cp (engine); Trimble (GPS); Versatron Cp (EO/IR)	Allison Engine/Rolls Royce; Aurora Flight Sciences; Boeing Rockwell; GDE Systems/Tracor; Héroux; Hughes Aircraft; L3 Com; Menasco; Raytheon E-Systems	ABS Cp; Advanced Composites; Aydin Vector; CI Fiberite; Hexcel; Honeywell Avionics; Litton G&C; L3 Com; Recon/ Optical; Rockwell Collins; Rosemount Aerospace; Northrop Grumman, Williams International

Developmental estimates

*1.2 kbps C2 (shared by 3 AVs); 2.5 kbps ATC (per AV)

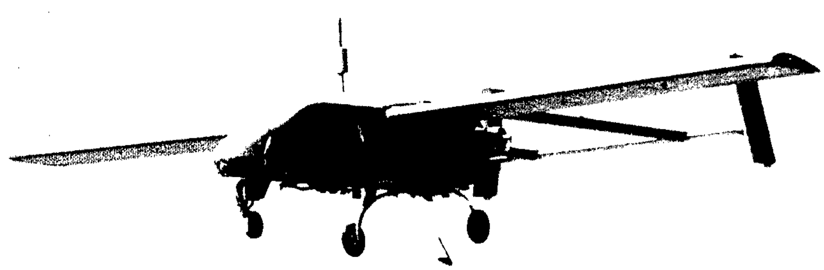
Legend:

ADR	Air Data Relay
A-Gear	Arresting Gear
ATC	Air Traffic Control
AV	Air Vehicle
AVGAS	Aviation Gasoline
C2	Comand and Control
CDL	Common Data Link
CGS	Common Ground Segment
CL	Command Link
DAMA	Demand Assigned Multiple Access
DEMPC	Data Exploitation, Mission Planning and Communications
EO	Electro-Optical
FLIR	Forward-Looking Infrared
GCS	Ground Control Station
GDT	Ground Data Terminal
GPS	Global Positioning System
GSE	Ground Support Equipment
HAE	High Altitude Endurance
IFF	Identification, Friend or Foe
INS	Inertial Navigation System
IR	Infrared
JP	Jet Petroleum
LHA	Landing Helicopter Amphibious
LHD	Landing Helicopter Dock
LOS	Line of Sight
LPD	Landing Platform Dock
LRE	Launch & Recovery Equipment
LRS	Launch & Recovery System
MAE	Medium Altitude Endurance
MMF	Mobile Maintenance Facility
MOGAS	Mobility Gasoline
MOSP	Multi-mission Optronic Stabilized Payload
MPS	Mission Planning Station
PCS	Portable Control Station
RATO	Rocket-Assisted Takeoff
RL	Return Link
RRS	Remote Receiving Station
RVT	Remote Video Terminal
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications (Military)
TCDL	Tactical Common Data Link
TML	Truck-Mounted Launcher
UHF	Ultra High Frequency

RQ-2A Pioneer

General

Pioneer was procured starting in 1985 as an interim UAV capability to provide imagery intelligence (IMINT) for tactical commanders on land and at sea. We continue to operate nine systems in the active force: the Navy and Marine Corps operate five and two systems, respectively, and two are assigned to Ft. Huachuca, AZ. In 12 years, *Pioneer* has flown nearly 16,000 hours. During Persian Gulf operations in 1990 – 91, it flew over 300 combat operations in support of the ground forces. Since 1994, it has flown missions over Haiti, Somalia, and Bosnia. The two Bosnia deployments (one afloat, one ashore) involved support of NATO peacekeeping forces, monitoring population centers, and searching for terrorists. Prime contractor is Pioneer UAV, Inc., Hunt Valley, MD.



Subsystems

- 5 Air Vehicles
- 1 Ground Control Station
- 1 Portable Control Station
- 4 Remote Receiving Stations (max)
- 1 Truck-Mounted Launcher

Key Operational Factors

Sensors:	EO or IR (EO and IR with new sensor)
Deployment:	Multiple[b] C-130/C-141/C-17/C-5 sorties; also shipboard
Radius:	185 km (100 nm)
Endurance:	5 hrs
Ceiling:	4.6 km (15,000 ft)
Cruise Speed:	120 km/hr (65 kts)

[b]Depends on equipage and duration

Flight Data[a]	**Bosnia**	**FY97**	**Total to Date**
• Flights / Hours	39 / 95	1,089 / 2,077	>5,100 / 15,815

[a]As of 30 Sep 97

Funding (Then-Year $M):	**FY97**	**FY98**
• Weapons Procurement, Navy		42.7
• Other Procurement, Navy	25.0	

FY 1997 Activities

With the Navy's decision to extend *Pioneer's* operational life to FY 2003 or until TUAV systems are fielded in quantity, the Service has continued to invest in spares and readiness improvements, to include subsystem upgrades.

Integration and testing of the UAV Common Automated Recovery System (UCARS) and Modular Integrated Avionics Group (MIAG) were completed in FY 1997. UCARS will improve UAV recovery operations, while MIAG will improve avionics functions for less weight and cost (see p. 36). Procurement of production UCARS and MIAG units will begin in FY 1998, along with a new buy of 15 AVs; fleet retrofits will be made thereafter.

PEO(CU) is currently acquiring two prototype and 20 production versions of a new EO/IR payload, which will improve performance and reliability at less weight. It is a modified Versatron 12DS (dual sensor: TV and forward-looking infrared [FLIR]), which will allow autotrack capability and on-the-fly selection of day or night sensors. The contract includes two options for 20 additional payloads, each.

A competition is underway for an alternate engine source to provide replacements for the Sachs SF2-350 engine, which is out of production. The intent is to increase engine reliability and power while minimizing impacts to AV configuration. A contract award is planned for December 1997.

These new subsystems will enhance *Pioneer's* contributions to naval and joint operations into the 21st century.

The fleet passed the 15,000-hour flying mark in July 1997. VC-6 was the first unit to exceed 1,000 hours in a single year, with 1,161.5 hours during FY 1997. NAMTRAGRUDET also broke its annual flight hour record with 577.9 hours.

Hunter

[During TF XXI,] Hunter demonstrated hands down the value of a tactical UAV under the control of the brigade commander.

*GEN Hartzog
CG, TRADOC
9 April 1997*

General

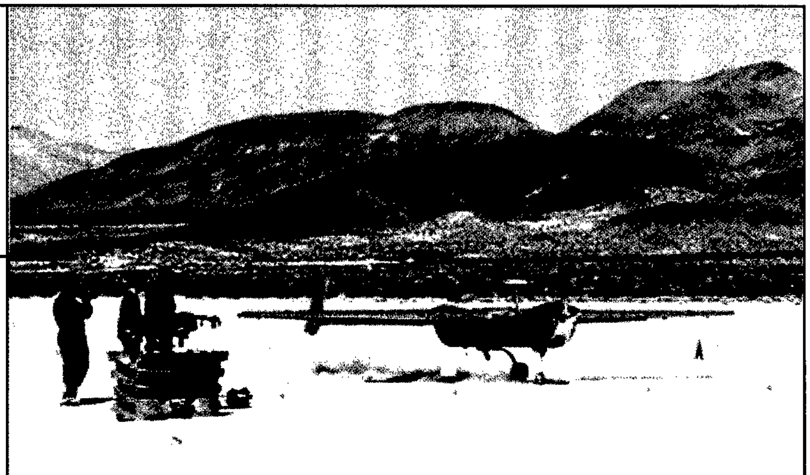
The *Hunter* UAV was originally developed to provide both ground and maritime forces with near-real-time IMINT within a 200-km direct radius of action, extendible to 300+ km by using another *Hunter* as an airborne relay. *Hunter* can operate from runways or unimproved air strips (200m x 75m and RATO launch) to support ground tactical force commanders. System production stopped in FY 1996 with delivery of the initial 7 systems; one full system supports the 15th Military Intelligence Battalion (MI Bn) at Ft. Hood, TX, and other assets support the Joint UAV Training Center at Ft. Huachuca, AZ. Prime contractor is TRW, San Diego, CA.

Subsystems

8	Air Vehicles
4	Remote Video Terminals
3	Ground Control/Mission Planning Stations
2	Ground Data Terminals
1	Launch and Recovery System
1	Mobile Maintenance Facility

Key Operational Factors

Sensors:	EO and IR
Radius:	267 km (144 nm)
Endurance:	11.6 hrs
Max Altitude:	4.6 km (15,000 ft)
Cruise Speed:	>165 km/hr (>89 kts)



Funding (Then-Year $M):	FY97	FY98
• Ops & Maintenance (Army)	17.4	16.2

Flight Data[a]	TF XXI AWE	FY97	Total
• Flights / Hours	56 / 282	558 / 1,973	2,152 / 6,607

[a]As of 30 Sep 97

FY 1997 Activities

Hunter continued to support Army and joint exercises and training (see pp. 7–10). In addition, a 4-AV "*Hunter* Lite" demo system, operated by contractor personnel, supports payload experiments and other exercises. Since resuming flight in December 1995, system performance and reliability have far exceeded original requirements. It has flown over 3,100 hours and its mishap rate has improved from 5.0 per 1,000 flight hours to 0.5 — a factor of ten.

Its operational demonstrations of the value of tactical UAVs have elicited strong praise from the user community. During TF XXI alone, for example, *Hunters* not only flew brigade support missions (as the TUAV surrogate), but also division support missions on request. Some missions combined Joint STARS' "big picture" surveillance and alerting with the UAV's capability to validate information and see the detail. *Hunters* provided adjustment of artillery fire, precise targeting and near-real-time BDA, while maintaining a readiness rate of above 90%. Their ability to keep the enemy force under stress helped to disrupt its operations while enabling the friendly force to accelerate its targeting and decision-making processes.

Other *Hunter* activities included:

- ❒ Support for multiple exercises at Fort Hood, TX, as contributions to evolving concepts and doctrine;
- ❒ The loan of four AVs to the Navy for CONOPS development and payload demonstrations at NAS Fallon, NV;
- ❒ Target acquisition for an Army Tactical Missile System (ATACMS) and Navy Tomahawk Operational Test launches;
- ❒ Laser designation for several Kiowa/Hellfire live missile shots (all direct hits); and, at NAS Fallon, designation for three Paveway munitions (also all hits); and
- ❒ Communications relay for units operating beyond line-of-sight (BLOS).

"Alpha Company and the Hunter system are the cream of the crop"

SecDef Cohen, speaking to 15 MI Bn soldiers at TF XXI AWE, 19 March 1997.

Outrider

General

The *Outrider* Tactical UAV (TUAV) is an Advanced Concept Technology Demonstration (ACTD) program to demonstrate a dedicated UAV reconnaissance system for Army brigade, Marine Air-Ground Task Force (MAGTF) and Navy commanders. To meet joint requirements, the TUAV needs to deliver timely and accurate reconnaissance, surveillance and target information at ranges up to 200 km and with on-station endurance up to 4 hours. *Outrider* is designed for both land-based and shipborne operations, with an automatic takeoff and landing capability for short, unimproved ground surfaces or large-deck amphibious ships. The ACTD involves a two-year cost-plus contract with a low-rate initial production (LRIP) option. Prime contractor is Alliant Techsystems, Hopkins, MN.

Subsystems

- 4 Air Vehicles
- 4 Modular Mission Payloads
- 2 Ground Control Stations and Data Terminals
- 1 Remote Video Terminal
- Launch & Recovery: Auto Takeoff and Landing
- Ground Support Equipment (incl. 2 HMMWVs/2 Trailers)

Key Operational Factors

Sensors:	EO and IR (SAR growth)
Deployment:	C-130/C-141C/C-17/C-5 sortie(s); also shipboard
Radius:	200 km (108 nm)
Endurance:	3.6/2.0 hrs on-station @ 100/200 km
Max Altitude:	4.6 km (15,000 ft)
Cruise Speed:	167 km/hr (90 kts)

Flight Data[a]	FY97	Total to Date
• Flights / Hours	9 / 2.3	9 / 2.3

[a]As of 30 Sep 97

Funding (TUAV) ($M):	FY97	FY98
• RDT&E, Def-wide – *Outrider*	46.0[b]	
• RDT&E, Army – *Outrider*		45.0

[b]Pending FY 1998 rescission

FY 1997 Activities

The past year was characterized by challenges for this demonstration program. Integration of nondevelopmental and commercial off-the-shelf (NDI and COTS) items to accommodate desired military performance parameters[7] required additional system engineering, integration, and trade-offs. These changes extended the ACTD's internal schedule by several months and incurred both Defense Department and Congressional concern. As a result of cost increases, four ACTD systems will be delivered in FY1998, vice the six originally planned.

A series of USD(A&T)-chaired program reviews, held in February, April, June and November 1997, provided oversight and direction to resolve the program's issues. Directed activities included pursuit of UCARS for the TUAV, Service study of alternative acquisition strategies to meet land and maritime TUAV requirements, and a survey of industry to assure their feasibility. Major system changes include:

- Rebaselining the air vehicle with a 13-ft wing and 11-ft fuselage;
- Redesigning the landing gear and air data terminal;
- Incorporating a new alternator and servo; and
- Incorporating a new gasoline engine to complete the ACTD, instead of the optional heavy fuel engine (HFE).

The direction to replace *Outrider's* initial, contractor-proposed HFE by a rotary gasoline engine both helped to reclaim flight profile performance losses and recognized that HFE technology was not yet available for application to small UAVs.[8] Concurrently, a series of flights validated key subsystems while program and performance trades were examined. Joint Staff, Army, Navy and Marine spokesmen all agreed that the TUAV is likely to meet their near-term requirements, although an alternative approach may be necessary to meet the Navy's longer-range sea-based on-station requirement. As a result, DoD strongly supported continuation of the ACTD and the Congress, while rescinding some FY 1997 funds and denying FY 1998 funds for the ACTD's LRIP option, has funded its completion.

During the past year, the C-band data link and EO/IR payload subsystems were validated aboard a helicopter, to include confirmation of data link capability beyond 200 km. The GCS, which enables mission planning, in-flight control of the air vehicle and sensor, and information product dissemination to users in the field, is undergoing acceptance tests. The GCS has participated in the Army's Force Exercise XXI and AWE at Ft. Hood, TX, during which tactical intelligence was provided through MUSE, the synthetic video simulation system. *Outrider's* GCS served a critical role by providing the commander with near-real-time information. It has demonstrated full compatibility with the Army's All-Source Analysis System (ASAS) and, with no downtime thus far, has demonstrated its reliability.

Recent Activity and Near-Term Plans

Flight test of the air vehicle's ground and flight handling subsystems continues. The contractor is refining the propulsion, electrical power and landing gear subsystems, validating basic operating procedures, and integrating other design changes.

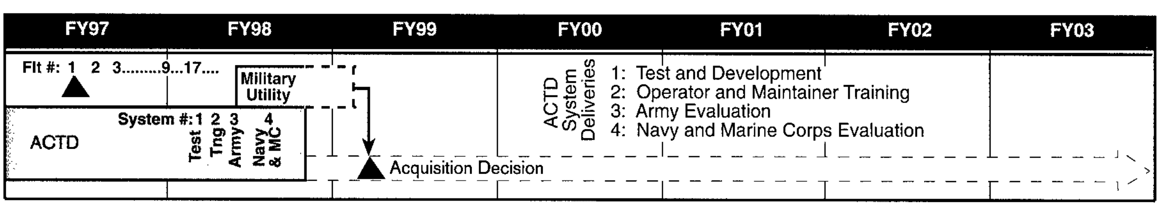
On 4 November, *Outrider* flew its 13th flight, the first with the new 801R rotary gasoline engine, built by UAV Engines Ltd (UEL), UK. Throughout this flight, it also used the Stability Augmentation System (SAS) from launch through recovery. By 16 November, *Outrider* had flown another four times, for a total of 17 flights and 5.7 hours. Full autopilot functionality evaluation begins in 1Q/FY 1998. Delivery of the first TUAV system for Military Utility Assessment will be made to Ft. Hood, TX, in 2Q/FY 1998.

Program decisions resulting from separate JROC and Acting USD(A&T) reviews on 3 November 1997 included:

- Reiteration by the JROC that TUAV is their number one UAV priority; and
- USD(A&T) continuation of the ACTD, and direction for another program update by 1 December with focus on system performance with the UEL gasoline engine, AV delivery status, and continuing analysis of acquisition alternatives.

The Services are currently developing acquisition approaches that will conform with the Congress's guidance and terms of the FY 1998 Budget, in preparation for the December 1997 USD(A&T) review.

Schedule

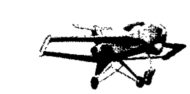


"For the past two years, the JROC has supported the development of a tactical UAV as its highest UAV priority...."

Gen Ralston, USAF
JROC Chairman
Letter to Congress
14 July 1997

"I am encouraged by the significant progress of the program over recent months ... We believe that the ACTD offers us the best and most prudent course of action at this time."

R. Noel Longuemare
Acting USD(A&T)
Letter to Congress
5 September 1997



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[7] Per 21 December 1995 Acquisition Decision Memorandum, which established the TUAV ACTD, the sole formal requirements dealt with meeting joint integration interface standards (now Defense Information Infrastructure/Common Operating Environment standards) and projected unit costs for single air vehicle and sensor: $350,000 for #33, and $300,000 for #100. The TUAV was to "come as close as possible" to meeting other basic requirements.

[8] Instead, a consolidated HFE development program under the DUSD(AT) was established to mature this technology independently of specific aircraft programs (see p. 37).

Tactical Control System (TCS)

"TCS is an essential building block for the long-term success of UAV technology. It combines the necessary requisites of affordability, mission effectiveness, and easy integration into all services' existing and planned C4I systems. It will be a key provider of joint interoperability for the United States and Allies."

RADM Barton Strong PEO(CU)

General

TCS is a DoD program to provide joint warfighters with a surface command, control, communications and data dissemination system for UAVs. It has made considerable progress over the past year and demonstrated initial functionality and versatility in a variety of land- and sea-based exercises.

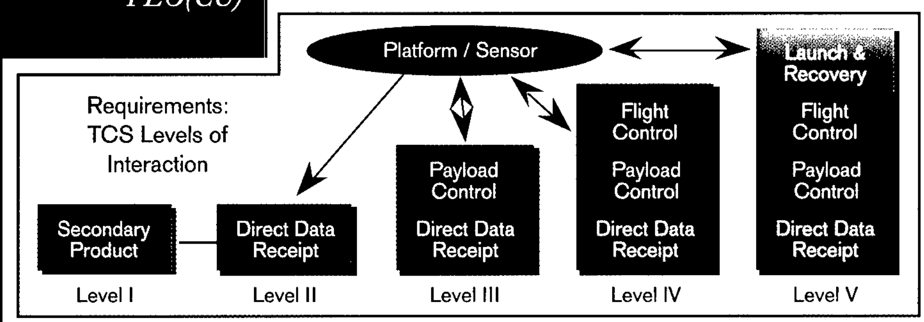
TCS is composed primarily of software, but also related hardware and additional ground/ship support equipment, to enable:

- ❒ Software interoperability on host-Service computer platforms;
- ❒ Five levels of scalable interaction, from passive imagery/data receipt to full AV control (see figure below); and
- ❒ Rapid imagery dissemination to tactical users through a variety of C4I system interfaces.

It is being designed as an open architecture system to facilitate future hardware and software enhancements and will comply with:

- ❒ ASD(C3I)'s Joint Technical Architecture;
- ❒ Distributed Common Ground System (DCGS) standards of the Common Imagery Ground/Surface System (CIGSS); and
- ❒ The Defense Information Infrastructure/ Common Operating Environment (DII/ COE).

Initially, TCS will be integrated with *Outrider* and *Predator* and will incorporate the five levels of interaction. Integration planning has also been initiated for *Pioneer* and *Hunter*. Subsequently, receipt of payload information from the HAE UAVs will enable TCS's rapid dissemination of their imagery and data to selected C4I systems. TCS thus provides a migration path to interoperable UAV employment with a common interface to the C4I infrastructure.



NATO is interested in TCS's range of flexible options for Alliance operations. The NATO Industry Advisory Group's Project Group 35 (NIAG PG/35) has initiated a study to define a common, interoperable NATO UAV GCS architecture. In September 1998, TCS will take part in an interoperability demonstration with a German UAV.

FY 1997 Activities

JROC Activity

The JROC fully supports TCS as critical to the successful development and employment of UAV systems (see p. 18). In JROCM 173-96, which updated UAV priorities, the JROC emphasized the need for commonality and interoperability in the control of UAVs and dissemination of their data .

Programmatic Activities

In January 1997, the Expanded Defense Resources Board (EDRB) approved $63 million in additional funding for FY 1998 – 03 to accelerate the program. TCS is being developed as a three-phase effort (see table above-right).[9]

Φ	Focus	TCS Units	Activities / Objectives
I	Program definition and risk reduction	3 Protypes	Software dev't; early ops assessments; MS II; integration contract
II	Engineering & Manufacturing Development (EMD)	6 LRIPs	Block 0 system test & integration; Block 1 design reviews; MS III
III	Production and Fielding	≈ 200 (projected)	Production; IOC; Block & P3I upgrades; ops testing; FOC; O&S

Phase I is an incremental build to demonstrate increasing TCS functionality from passive receipt of data to payload and multi-UAV control. Its three fieldable prototypes represent the various TCS operational environments: sea-based, HMMWV-shelterized, and in a Tactical

[9] The Block 0 TCS will demonstrate the five levels of interaction by the end of Phase I.

Operations Center (TOC). **Phase II** will continue demonstrations and acquire six low-rate initial production (LRIP) systems for an Initial Operational Test and Evaluation (IOT&E) program. **Phase III** will include production, support, preplanned product improvements (P3I), and incorporation of additional C4I interfaces.

In March 1997, contracts were awarded to General Atomics and Alliant Techsystems for TCS integration into *Predator* and *Outrider*, respectively. In November, Logicon was selected to provide an off-the-shelf TCS Mission Planner. An RFP for a TCS Systems Integrator is planned for release to industry in 2Q/FY 1998, with contract award in 4Q/FY 1998.

In coordination with DARO, the Assistant Secretary of the Navy (Research, Development and Acquisition) (ASN(RD&A)) formed an Acquisition Coordination Team (ACT) to support the TCS program after designating it an ACAT II program on 12 September 1997.

Funding (Then-Year $M):	FY97	FY98
• RDT&E, Defense-wide	6.3	42.5[a]

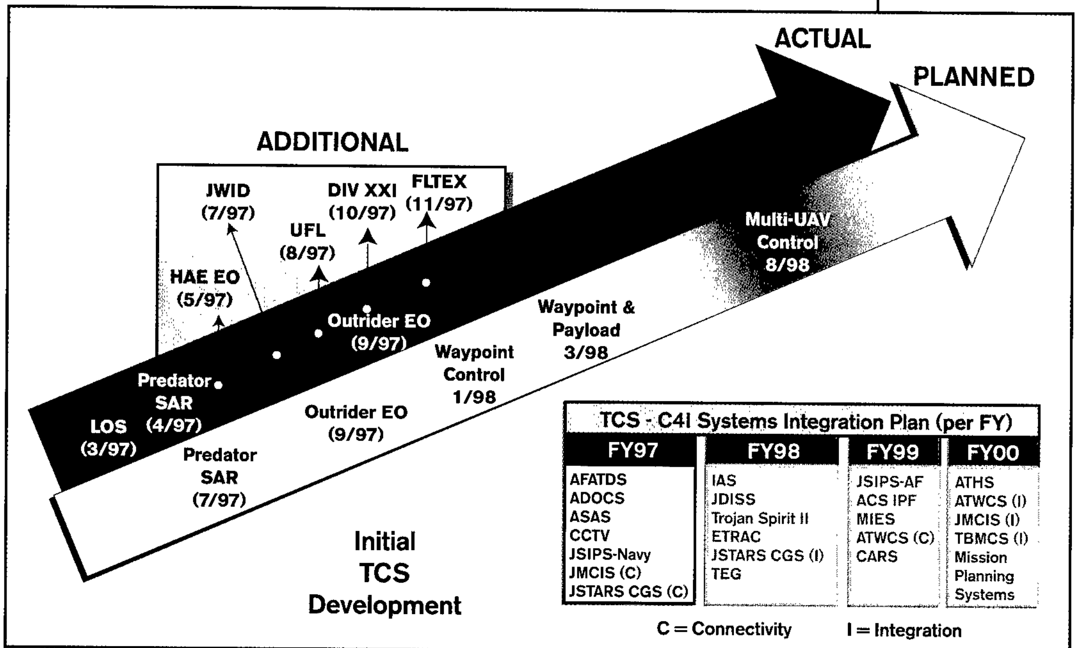
[a]Includes Congressional addition for Predator AV and GCS

"TCS, when fielded, will be a valuable tool in the joint warfighters' range of capabilities."

U.S. Atlantic Command, Norfolk NAS, VA

Demonstrations

A TCS prototype took part in the Army's TF XXI AWE in March 1997 (see p. 8). During April and May lab demonstrations, TCS showed it could receive *Predator* SAR and *DarkStar* EO data, respectively. It hosted demonstrations at several locations, including the Pentagon. During Joint Warrior Interoperability Demonstration 1997 (JWID-97) in June, it was used in a sensor-to-shooter interoperability demonstration aboard the USS Stennis. In mid-summer, it performed shipboard data receipt and dissemination of simulated UAV payload imagery generated by MUSE.[10] In August, TCS/MUSE supported the Army's Exercise Ulchi Focus Lens 97 (see p. 9).



TCS's use during exercises has shown operators at all levels what it can do and what is planned for the future. In addition, the exercises demonstrated successful data distribution to various C4I nodes and also provided valuable feedback to developers.

Near-Term Plans

With enactment of its FY 1998 budget, the TCS Program Office will:

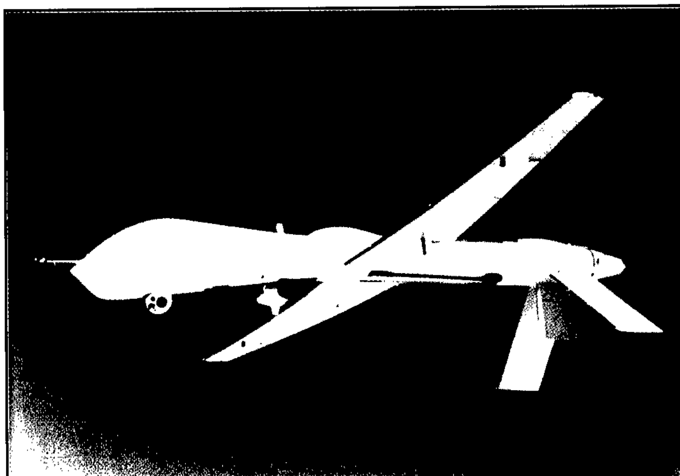
- ❒ Continue functionality demonstrations of land- and sea-based TCS units;
- ❒ Procure a *Predator* AV and GCS with additional funds provided (see p. 3);
- ❒ Select a TCS/LRIP System Test and Integration contractor;
- ❒ Downselect for mission and payload planning application;
- ❒ Complete the TCS TEMP;
- ❒ Coordinate TCS incorporation into the *Pioneer* and *Hunter* programs;
- ❒ Participate in joint warfighting and Service experiments and exercises, to include *Predator* and *Outrider* demonstrations; and
- ❒ Engage in multi-UAV simulation efforts.

[10] Multiple UAV Simulation Environment (see p. 39).

RQ-1A Predator

General

Predator, formerly known as the Medium Altitude Endurance (MAE) or Tier II UAV, is a derivative of the *Gnat 750* (Tier I) UAV. The system provides long-range, long-dwell, near-real-time imagery intelligence (IMINT) to satisfy reconnaissance, surveillance and target acquisition (RSTA) mission requirements. The air vehicle carries both EO/IR and SAR sensors which, with a Ku-band satellite communication (SATCOM) links, enable the system to acquire and pass highly accurate imagery to ground stations for theater-wide use by tactical commanders. *Predator* redeployed to Taszar, Hungary, in March 1996 to support NATO operations in Bosnia and has been there ever since. On 30 June 1996, *Predator* completed its 30-month ACTD program and in August 1997 transitioned to a production program in the formal acquisition arena. Prime contractor is General Atomics – Aeronautical Systems, Inc., San Diego, CA.



Subsystems

4 Air Vehicles (per production system)
1 Ground Control Station
1 Trojan Spirit II Dissemination System
Ground Support Equipment

Key Operational Factors	
Sensors:	EO, IR and SAR
Deployment:	Multiple[b] C-130 sorties
Radius:	740 km (400 nm)
Endurance:	≈35 hrs
Max Altitude:	7.6 km (25,000 ft)
Cruise Speed:	120-130 km/hr (65-70 kts)

[b]Depends on equipage and duration

Flight Data[a]	Bosnia	FY97	Total to Date
• Flights / Hours	607 / 3,742	595 / 2,613	1,504 / 6,756

[a]As of 30 Sep 97

Funding (Then-Year $M):	FY97	FY98
• RDT&E (Defense-wide)	7.8	
• RDT&E (AF)		15.0
• A/C Procurement (AF)	107.8	141.5
• Other Procurement (AF)	2.9	
• Other Procurement (Navy)	5.6	
• Military Construction (AF)	4.7	
• Ops & Maintenance (AF)	5.5	18.6
• Military Personnel (AF)	7.3	20.0

One of the big reasons that there's peace in Bosnia today is because of the technology like this, that ferrets out the weapons and lets the other side know that we know where they are ...

Randy "Duke" Cunningham
U.S. Rep, CA
51st District

FY 1997 Activities

Predator met two challenges successfully this past year. First, residual ACTD assets continued full support of NATO operations in Bosnia (see pp. 4-5), which precluded their participation in most other activities at home. Secondly, the program transitioned to production, the first ACTD to enter the formal acquisition process.

On 2 January 1997, the USD(A&T) authorized limited procurement by the Air Force (through the Navy's PEO(CU)) to sustain the post-ACTD residual assets, to include:

- ❒ One AV to replace one that had crashed;
- ❒ Five additional AVs and three Trojan Spirits to complete the existing systems (as redefined); and
- ❒ Their necessary support.

Thirteen months of transition activities focused on resolving key issues with respect to requirements, acquisition approach, force size and funding, reliability and support, and configuration upgrades. There were no short cuts to *Predator's* production approval. System trades and follow-on developments and tests were incorporated into the program to meet both joint and lead-Service requirements for system performance and sustainability. Other activities included a life-cycle cost (LCC) analysis,[11] and a Lease vs. Buy study (with the recommendation to "buy"). Further, lessons learned during *Predator's* ACTD and transition have been documented for other ACTD programs (see pp. 16-17).

On 8 August 1997, the Defense Acquisition Board approved *Predator's* entry into the production phase of the acquisition process, designated the program as Acquisition

[11] 12-System LCC:
(Base-year FY 1996 $M)
• RDT&E 213
• Production 512
• O&S, etc. 697
– Total: 1,422

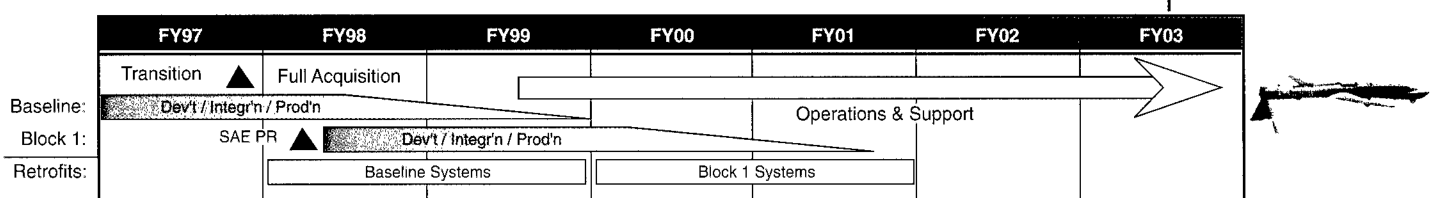
Category II (ACAT II), and delegated milestone decision authority (MDA) to the Air Force.[12]

Documentation	Authority	Approved
Operational Assessment (in ACTD)	ACC	24 Jun 96
Key Performance Parameters (KPPs)	JROC	3 Jul 97
Operational Requirements Document (ORD)	JROC	3 Jul 97
Single Acquisition Management Plan (SAMP)	SAF/AQ	21 Jul 97
Acquisition Program Baseline (APB)	SAF/AQ	7 Aug 97
Test and Evaluation Master Plan (TEMP)	DOT&E	(1Q/FY98)

The approved *Predator* program includes a total of 12 systems, with a block-upgrade program to phase in additional P3I capabilities. The Air Force has initiated a streamlined acquisition process by eliminating as much government furnished equipment (GFE) and government contracting as possible, and by giving total system performance responsibility (TSPR) to General Atomics. The Service plans a program review (PR) to initiate production of systems #9 and #10 early in FY 1998; procurement of systems #11 and #12 are planned for FY 1999 and 2000, respectively. With Congressional approval of the FY 1998 budget request, the program is fully funded for FY 1998, and resources are fully programmed for the out-years.

[12] USD(A&T) *Predator* UAV Acquisition Decision Memorandum, August 18, 1997.

Schedule



Configuration Management

Another noteworthy outcome of Predator's transition planning is its evolution to a more capable system much earlier in the acquisition process. A year ago, just three features were considered essential for a production baseline configuration, though many others were identified as P3I candidates. Now, seven features will be in or retrofitted to the Baseline configuration, with an additional five incorporated into the Block I acquisition. Although funding was available for 13 systems, the Air Force chose to fund 12 better-quality systems, with progressive improvements in sustainability, from the outset. Block I capabilities are planned for first delivery with system #10 in FY 2000.

Configuration Feature	Remarks
Baseline (Post-ACTD):	
• De-ice Systems	– Required for all-weather operation
• Rotax 914 Engine	– Improved performance (over 912)
• Air Traffic Control – Voice	– For communications with ATC
• Mode IV IFF	– Positive airborne control requirement
• Relief on Station (ROS)	– Two UAVs controlled from one GCS
• GCS Repackaging	– Improved equipment for fielding
• R&M Improvements (I)	– To meet ORD requirements
Block 1 (Production)	
• GCS Comms / Red/Black	– Secure and unsecure communications
• Tactical Control System	– For interoperability with C4I
• AF Mission Support System (AFMSS) Interface	– Compatibility with another Air Force ground station
• R&M Improvements (II)	– To meet ORD requirements
• UCARS	– To enhance operational safety

Note:

FY 1996 transition planning envisioned an LRIP program prior to full production, with only a few of these features planned as P3I items.

Predator and Maritime Operations

The Congressionally directed *Predator* Marinization Feasibility Study was reported to the Congress in January 1997. The study concluded that fully marinizing *Predator* for launch and recovery aboard "large deck" naval platforms, though feasible, would incur significant modifications, testing, and costs. Accordingly, the Navy decided not to develop *Predator* on-board capabilities, but to continue demonstrating MAE UAV technologies from shore-based locations. This will augment its evolving concept for UAV support for carrier battle groups and Marine Expeditionary Forces to the extent of their weapon ranges and aircraft capabilities.

RQ-4A *Global Hawk*

General

Global Hawk, formerly identified as the Conventional High Altitude Endurance (CONV HAE) or Tier II+ UAV, is planned as the HAE UAV "workhorse" for missions requiring long-range deployment and wide-area surveillance or long sensor dwell over the target area. It will operate at ranges up to 3,000 nm from its launch area, with on-station loiter capability of 20 hours (at that range) at altitudes exceeding 60,000 ft. It will employ both EO/IR and SAR sensors to generate both wide-area and spot imagery while standing off from high-threat areas. It will have both LOS and satellite data link communications. The HAE Common Ground Segment (CGS) (see p. 35) provides both launch and recovery and its mission control elements (LRE and MCE), which are common and interoperable with *DarkStar*. The ACTD is in Phase II, which comprises fabrication and an extensive system test program to assure AV subsystem functions and AV-ground segment integration, to demonstrate system capabilities, and to reduce risk. Prime contractor is Teledyne Ryan Aeronautical (TRA), San Diego, CA.

Subsystems
Air Vehicles (TBD)
1 Common Ground Segment
Flight #1: Scheduled for January 1998

Key Operational Factors			
Sensors:	EO, IR and SAR	Radius:	5,556 km (3,000 nm)
Deployment:	AV: self-deployable; multiple C-141/C-17/C-5 sorties for other equipment[a]	Endurance:	38 hrs (20 hrs at radius)
		Max Altitude:	19.8 km (65,000 ft)
		Cruise Speed:	639 km/hr (345 kts)

[a]Depends on equipment deployed and deployment duration

Funding (Then-Year $M):	**FY97**	**FY98**
• RDT&E (Defense-wide)	67.8	96.0

FY 1997 Activities and Flight Preparations

ACTD Component	Adjustment
• *Global Hawk*	8 to 5
• *DarkStar*	6 to 4 *
• HAE CGS	3 to 2

* Including AV-1 (crashed April 1996)

Following ACTD Phase II contract award in May 1995, the TRA team fabricated the first two AVs and performed subsystem and system integration tests throughout the year. AV-1 will be used for airworthiness evaluations and full flight envelope demonstration, while AV-2 will carry the full sensor suite for system evaluations.

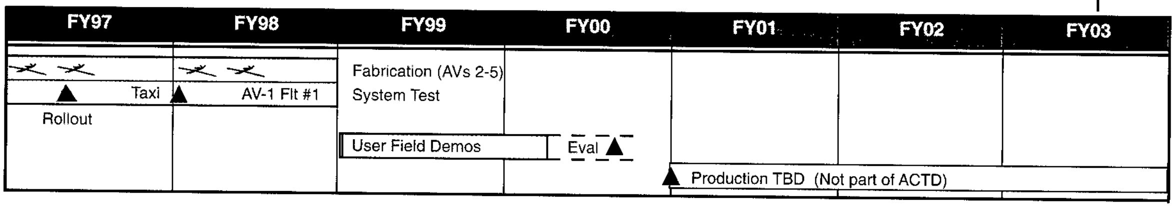
In a USD(A&T)-directed approach to remain within available ACTD funding, air vehicle production has been reduced and Phase III shortened from 24 to 15 months.

Rollout of AV-1 took place at TRA's San Diego, CA, facility on 20 February 1997. By then, almost all subsystems required for first flight had been installed, but the full system's software development and integration required more time. On 28 August, TRA transported AV-1 to the Air Force Flight Test Center at Edwards AFB, CA. During the next few weeks, the system was reassembled and functionally retested. Taxi testing began in October, with AV-1's first flight planned for January 1998.

1997	Subsystem Milestones
Jan	Successful test of environmental control systems
Jan	Delivery of first Integrated Mission Management Computers (IMMCs)
Mar	First "live" engine run (following initial dry and wet checks)
Apr	Flight test mission profile simulated (using LRE, System Integration Lab), and communications system simulators (connected by Ethernet)
Apr	Final software integration and testing in preparation for Flight #1
Jul	Ground testing for electromagnetic interference (EMI) characterization
Aug	AV-1 relocated to Edwards AFB, CA, for taxi and flight tests
Oct	SAR flight tests initiated on A-3 test aircraft
Oct	All AV-1 subsystems rechecked for flight readiness. Initial taxi tests

A Strategic Asset with Which to See "The Big Picture"

Schedule



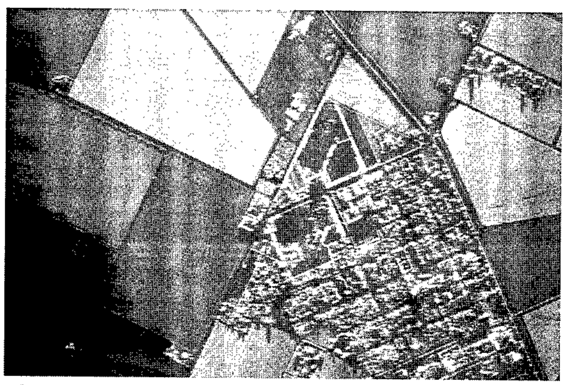
Near-Term Plans

Phase II will extend to 1Q/FY 1999, followed by Phase III, Test and Field Demonstrations, which will enable early user involvement in both technical and operational demonstrations to evaluate military utility.

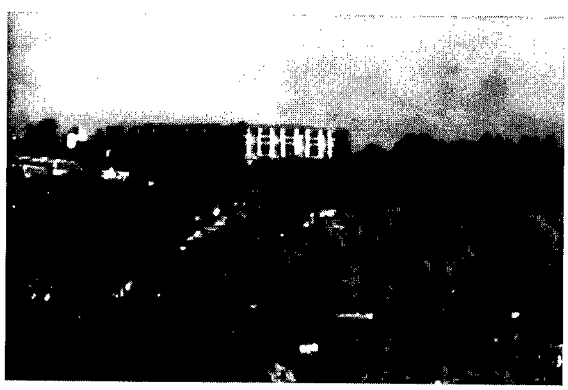
Program management is scheduled to transition from DARPA to an Air Force joint program office during the second half of FY1998. In addition, the following processes have been put in place:

- ❐ Early user participation is reflected by extensive Air Force involvement in the DARPA ACTD; and
- ❐ Early establishment of a sustainment team will ease *Global Hawk's* transition to an acquisition program and eventual operations (in the event of a favorable ACTD exit decision).

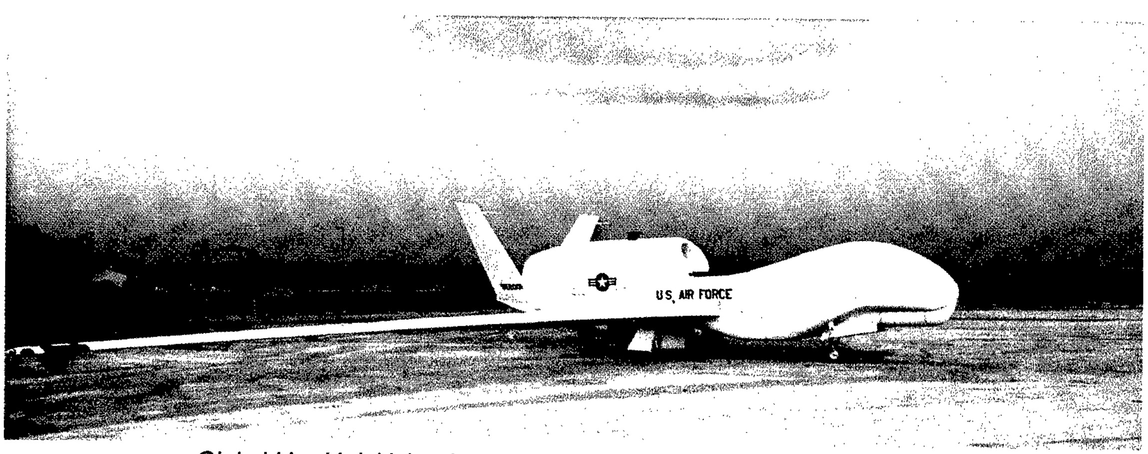
Phase II will consist of a series of airworthiness flights by AV-1 and -2, followed by EO/IR and SAR payload flights by AV-2. Following demonstration of basic system abilities to fly safely and relay imagery to the ground, AV-1 and -2 will enter Phase III, flying in their first joint exercise in January 1999. AV-3, -4 and -5 will join them in flying more than 50 sorties and 1,000 hours over the ensuing 12 months for users to assess *Global Hawk's* military utility by the time the HAE ACTD ends on 31 December 1999.



SAR image of Tranquillity, CA, at 65 km (35 nm)



EO imaging of Palos Verdes Estates, CA, at 21 km



Global Hawk's initial taxi test at Edwards AFB, CA, 16 October 1997

At *Global Hawk's* rollout ceremony, 20 February 1997:

"Global Hawk, *with its 14,000 nautical mile range ... will become a strategic asset ... to see the 'big picture,' to see it broadly, and to see it clearly."*

Dr. Kaminski, USD(A&T)

" 'One peek is worth a thousand sweeps'... if you can get your eyeball on the target, it's worth a thousand sweeps of your radar, and what this vehicle promises to give us is that peek, that visibility, into what is going on across our battlefield, so that our forces can have that precious commodity that we call 'situational awareness.' "

Gen Richard E. Hawley Commander, ACC

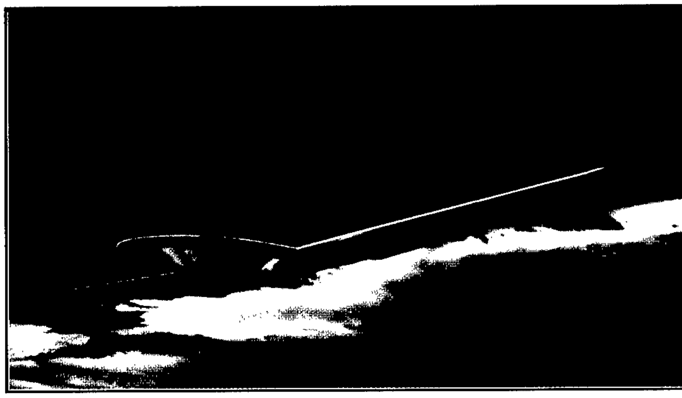
Information Dominance is a necessary element for ... winning quickly, decisively, with few casualties. And ... I think Global Hawk *can be a key element of doing that.*

Lt Gen George K. Muellner Princ. Dep. SAF/AQ

RQ-3A *DarkStar*

General

DarkStar, formerly identified as the Low Observable High Altitude Endurance (LO HAE) or Tier III– UAV, is designed to provide critical imagery intelligence from highly defended areas. With its use of low observable technology to minimize the air vehicle's detectability, *DarkStar* trades air vehicle performance and payload capacity for survivability features against air defenses. Its payload is either SAR or EO. The air vehicle may be self-deployable over intermediate ranges. The HAE Common Ground Segment (CGS) provides launch and recovery and mission control elements (LRE and MCE), which are common and interoperable with *Global Hawk. DarkStar's* prime contractor is the Lockheed Martin/Boeing team.



Subsystems	
	Air Vehicles [TBD]
1	Common Ground Segment

Key Operational Factors	
Sensors:	EO or SAR
Deployment:	Multiple C-141/C-17/C-5 sorties
Radius:	>926 km (>500 nm)
Endurance:	12 hrs (8 hrs at radius)
Ceiling:	15.2 km (50,000 ft)
Cruise Speed:	556 km/hr (300 kts)

Funding (Then-Year $M):	FY97	FY98
• RDT&E, Defense-wide	55.1	54.6

FY 1997 Activities and Flight Preparations

EO imagery of the San Francisco Bay area, CA

DarkStar's Flight #2 crash (22 April 1996, following its successful first flight in March) led to several design and control changes to correct the porpoising motion that induced the crash and to make the flight control system more robust. The system changes were extensively modeled and incorporated into AV-2, which was converted to flight status after completing radar cross-section testing.

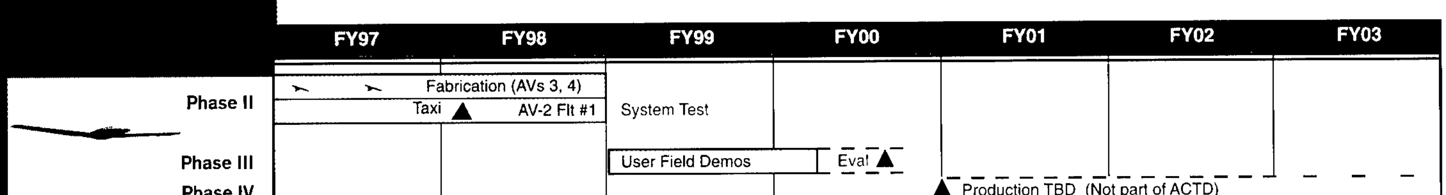
Other accomplishments included:

- ❐ A highly successful EO camera test (aboard a C-130 aircraft; see imaging of San Francisco at left);
- ❐ Critical air vehicle control and reliability modifications; and
- ❐ Upgrades to computers and the flight simulator.

Meanwhile, AV-3 and -4 are being fabricated for Phase III, Test and Field Demonstrations, which is now scheduled to begin in FY 1999.

DarkStar AV-2 was transferred to the NASA Dryden Flight Research Center, at Edwards AFB, CA, in October 1997, completes taxi tests in December, and is poised for a resumption of the flight test program early in 1998.

Schedule

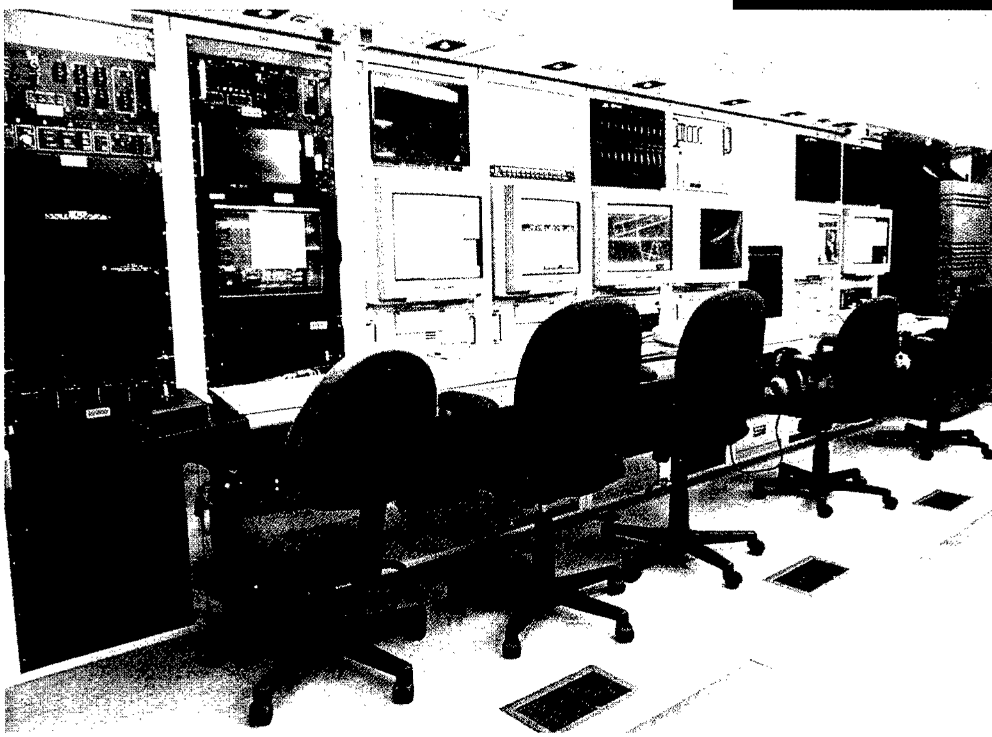


HAE Common Ground Segment

Funding (Then-Year $M):	FY97	FY98
• RDT&E, Defense-wide	57.8	42.1

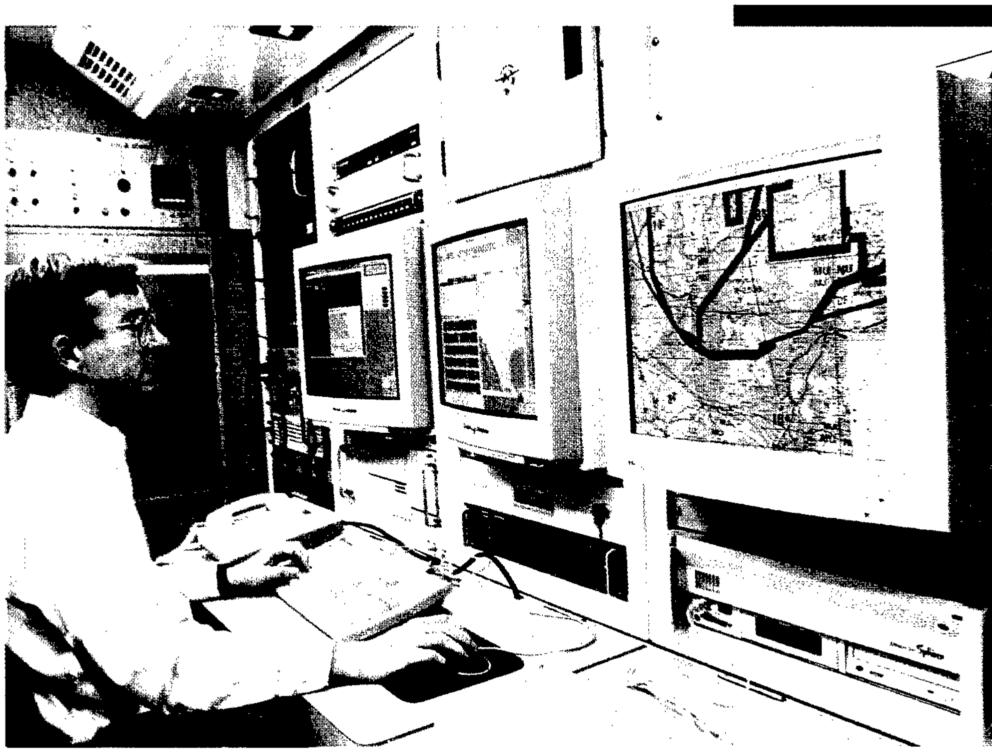
Note: Other common, but non-CGS-related, costs are budgeted in this line. These include government test and evaluation efforts and program office support, studies, and related tasks.

The third part of the HAE UAV system is its Common Ground Segment (CGS), which controls both HAE AVs. The CGS includes a Launch and Recovery Element (LRE), a Mission Control Element (MCE), a *DarkStar* Data Processing Element (DS DPE), associated communications, maintenance and support elements. The LRE prepares, launches and recovers the AV. The MCE plans and executes the mission, dynamically re-tasks the AV (including its sensors), and processes and stores or disseminates imaging and ground MTI data.



HAE CGS Mission Control Element (MCE)

The HAE CGS will be able to control up to three HAE UAVs at a time by LOS data link and SATCOM relay, thus enabling a single system to maintain a continuous presence over many days and at extended ranges from the operating site. The AVs will transmit digital imagery to the MCE (and TCS) via wideband LOS or satellite links for initial processing and relay to theater and/or CONUS imagery exploitation systems (IESs) using standard (CIGSS-compliant) formats. Selected reports and imagery frames will be able to be broadcast directly. When linked with systems such as the Joint Deployable Intelligence Support System (JDISS) and the Global Command and Control System (GCCS), such unexploited digital imagery will be transferable in near-real-time to the operational commander for immediate use. Thus, the HAE CGS will provide digital, high-quality imagery to warfighters and users at various command levels.



HAE CGS Launch and Recovery Element (LRE)

During the ACTD's Phase III, the full HAE UAV system will take part in exercises, demonstrations, and possible contingency deployments. The MCE and LRE pictures (above-right) show the Ground Segment's progress from last year's designs to this year's hardware.

Subsystems

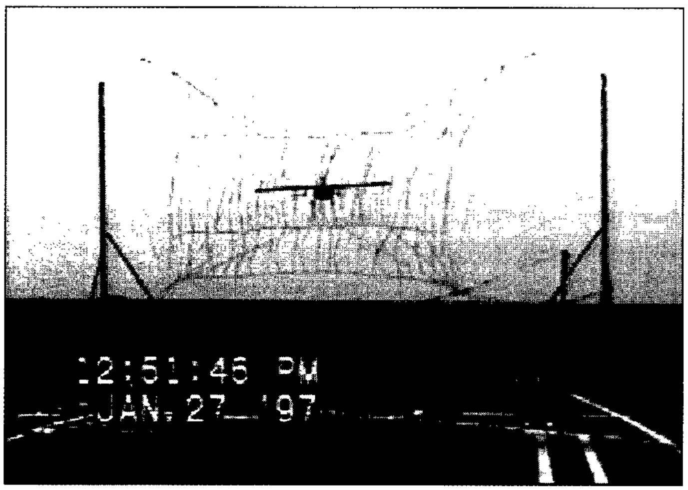
Key Subsystem Programs

UAV Common Automated Recovery System (UCARS)

UCARS has been developed to improve the precision, ease and safety of UAV recoveries, both on land and afloat, and in most kinds of weather and operating conditions. UCARS comprises a common position sensing system (provided by Sierra Nevada Corp., Reno, NV) and UAV-specific guidance and control software (developed by each UAV's prime contractor). The position sensing system is a millimeter-wave transponder tracking radar.

From September through December 1996, UCARS was successfully ground- and flight-tested aboard VC-6's *Pioneer* system at Webster Field, MD. Shipboard flight testing aboard the USS Shreveport, 20 – 31 January 1997, resulted in seven successful net recoveries and fully demonstrated UCARS' operational utility. Suitability testing of the first production UCARS unit began in May 1997. It will be fielded on *Pioneer* in FY 1998 – 99.

UCARS integration into *Outrider* began in FY 1997, while *Predator* integration will be started in FY 1998. A VTOL-UCARS demonstration is an option of the VTOL BAA (see p. 11). TCS will also incorporate the ability to recover AVs using UCARS.



UCARS-aided *Pioneer* recovery aboard the USS Shreveport


UCARS Track Subsystem

Modular Integrated Avionics Group (MIAG)


MIAG (left) will replace the components at right, plus wiring (not shown).

MIAG is a new, lightweight avionics package designed to replace multiple UAV avionics subsystems, improve UAV flight performance, and reduce weight and cost. Its initial application is on *Pioneer*. The 15-lb MIAG unit's functions include primary and backup navigation, flight stability control and processing, engine interface and control, mission loading and verification, payload control, Mode 4-capable Mark XII IFF, in-flight mission updating, data link management, built-in test and monitoring, and internal power sources. This multi-subsystem upgrade will increase many-fold the reliability of the relevant *Pioneer* functions, improve the AV's center of gravity, and reduce weight by up to 40 lb. This in turn will make room for larger payloads.

A MIAG engineering development model was integrated with Pioneer and flown successfully in July 1997. Production and full *Pioneer* fleet retrofit are planned, with the first incremental contract award in mid-FY 1998. Prime contractor is Lear Astronics, Santa Monica, CA.

Tactical Common Data Link (TCDL)

The objective of the TCDL program is to develop a lightweight, low-cost, CDL-interoperable data link for smaller UAVs and selected manned reconnaissance aircraft. The TCDL will support air-to-surface transmission of radar, imagery, video and other sensor information at ranges up to 200 km. It will interoperate with existing CDL systems operating at the 10.71-Mbps return link and 200-kbps command link rates. Programmable TCDL design features will enable the system to operate at up to 45 Mbps using commercial products and waveforms, while still retaining CDL interoperability.

TCDL program goals are to:

- Increase capability of, and lower costs and increase competition for, CDL-interoperable equipment; and
- Emphasize an open systems architecture using state-of-the-art communications technology and COTS systems and components.

Its six-month Phase I design study for the began in May 1997 with awards to three contractor teams:

- L3 Com and Rockwell Collins;
- Harris, GEC Marconi-Hazeltine, and TSI; and
- Motorola, Raytheon E-Systems, and Cubic.

Phase II's design, build and test work will start in January 1998. The goal of Phase II is to develop multiple TCDL-certified vendors.

Heavy Fuel Engine (HFE)

DoD HFE Development Program

Following the June 1997 USD(A&T) decision to remove the HFE option from the TUAV ACTD, a separate HFE development project has been established under DUSD(AT). A committee representing several OSD and Service offices met to focus DoD and industry efforts on HFE maturation and application to relatively small platforms, from UAVs to a variety of surface vehicles and equipment. At this stage, a common HFE family appears infeasible, due to the lighter weight-to-power density of 1.5 lb/hp for UAVs vs. 2.5 lb/hp with more stringent emission requirements for ground vehicles, and also projected differences in load requirements, cooling, and production quantities. However, significant common technology applications at the subsystem and component level show promise (e.g., for compressors, fuel pumps, injectors, rings, and perhaps even pistons, rods, and valves). The committee believes that it may be feasible to develop a prototype HFE for UAVs based on current lightweight automotive engine work that meets TUAV requirements.

Commercial HFE Initiatives for UAVs

Some companies are already pursuing their own HFE initiatives for their UAVs:

- **HFE Demo for *Pioneer*.** In October 1997, PEO(CU) contracted with Sonex Research Inc., Annapolis, MD, to convert two *Pioneer* gasoline-fueled engines to heavy fuel and demonstrate their operation in April 1998. This award follows Sonex's flight demonstration of a smaller engine conversion for the Naval Research Laboratory.
- **HFE for *Predator*.** General Atomics has an in-house effort to develop an HFE for *Predator*.
- ***Hunter* HFE Development.** The Williams HFE that was being developed for *Hunter* may also have potential for other UAVs (including *Predator*). The Williams HFE had progressed to Critical Design Review (CDR) before the effort was halted as part of the *Hunter* UAV program termination.

UAV Mission / Payload Prioritization

In last year's Report, we noted the initiation by the JROC's UAV Special Studies Group (SSG) of its follow-on UAV payload prioritization work, according to UAV and projected mission or capability areas. This past year, the UAV SSG iterated both mission priorities and payloads by UAV with the Service and operational CINC staffs to develop a consolidated set of recommendations to suggest future technology investment. Current status is reflected below.

First, the CINCs prioritized the missions (at left) for each of the four future-force UAVs, as shown. Reconnaissance in all its major aspects is clearly seen as the primary warfighting role for all UAVs, no matter what their capabilities or operating régime. The other missions may have higher or lower priorities for each UAV, depending on that UAV's characteristics. Payloads that have already been defined for specific UAVs and roles are shown in color. UAV-specific considerations are below the table.

Mission	TUAV	Predator	Global Hawk	DarkStar
Reconnaissance – Improved Day / Night All-Weather Surveillance – Improved Target Geolocation – Battle Damage Assessment (BDA)	1	1	1	1
Signals Intelligence (SIGINT)	6	2	2	3
Mine Countermeasures	2	6	12	10
Target Designation	3	3	9	2
Battle Management	4	8	7	6
Chemical/Biological Reconnaissance	5	10	11	9
Counter-Camouflage/Concealment/Deception	7	4	6	4
Electronic Warfare	8	7	4	8
Combat SAR [Search and Rescue]	9	5	10	5
Communication / Data Relay	10	9	3	11
Information Warfare	11	11	5	7
Digital Mapping	---	12	8	12
UAV Mission-Payload Considerations	Improve current sensors to support economic, rapid fielding of upgrades		Emphasize "plug and play" sensors (see below) Create LOS comm/data relay within Theater	Emphasize sensors that take advantage of DarkStar's stealth attributes

Mission payload defined

CINC/Service UAV Mission Prioritization

Notional consolidated UAV-payload lists have been developed for each operating régime — Tactical and High Altitude — as options for post-ACTD program decisions. Cost and schedule factors were included to test for feasibility and affordability. These lists are shown at left. *Outrider* and *Predator* were envisioned in more tactical roles, while *Global Hawk* and *DarkStar* would perform in scenarios that required high operating altitudes. The mission functions that each UAV-payload option could perform are shown in the right column.

Notional Future Payloads

	UAV	Payload	
TACTICAL	Predator	Improved Video (EO/IR)	Recce, BDA, Day/Night (D/N) Adverse Wx
	Outrider	Improved IR (MWIR)	Recce, D/N Adverse Wx, BDA
	Outr / Pred	Digital Data Link	(Sensor-Dependent)
	Outrider	SAR / MTI [a]	Recce, D/N All-Wx, Impvd Tgt Geoloc, BDA
	Predator	Improved LWIR	D/N Adverse Wx, Recce, BDA
	Predator	MTI Radar [a]	D/N All-Wx, Recce, Impvd Tgt Geo, BDA
	Outrider	Mine CM: Land,[a] Beach	Recce, Mine Countermeasures
	Outr / Pred	Comm / Data Relay	Comm / Data Relay
	Global Hawk	JSAF Payload (SIGINT) [b]	Recce, SIGINT
	Global Hawk	Airborne Comm Node	Comm / Data Relay
	Global Hawk	ASARS Impv Pgm (AIP) [b]	D/N All-Wx, Recce, BDA
	Global Hawk	EO / IR (SYERS MSI) [b]	Recce, BDA, Counter-Camou / Con / Decep
	Global Hawk	Interferometric SAR	Recce, Tgt Geolocation, Digital Mapping
	DarkStar	Add IR	D/N Adverse Wx, Recce, BDA
	DarkStar	Laser Designator	Tgt Geolocation, Tgt Designation
	Global Hawk	FOPEN Radar	D/N All-Wx, Recce, Counter-CCD
	Global Hawk	Stand-off Jammer	Electronic Warfare
	DarkStar	Improved SAR Resolution	D/N, All-Wx, Recce, BDA
	Global Hawk	ESM Imagery Cueing	D/N, All-Wx, Recce, ELINT, Impvd Tgt Geo
	Global Hawk	Impvd Squint SAR (GH)	D/N, All-Wx, Recce, BDA
	Global Hawk	Impvd GMTI Mode (GH)	D/N, All-Wx, Recce
	Global Hawk	Imp Resol SAR (2x) (GH)	D/N, All-Wx, Recce, BDA
	DarkStar	Add GMTI Radar	D/N, All-Wx, Recce

[a] Requires Digital Data Link [b] Integration for "Plug and Play" with U-2 and Air Force Special Platform

Some payloads will need corresponding improvements in communication links and data-processing capabilities, whether on- or off-board the UAV, to capitalize on the payload's capability; for simplicity, these are not shown. In addition, some manned platform payloads are being considered for UAVs also, such as improved SIGINT, Advanced Synthetic Aperture Radar System (ASARS) and Senior Year Electro-optical Reconnaissance System Multi-Spectral Imagery (SYERS MSI).

Payload Test and Demonstration Programs

At the hardware application and integration level, payload testing and demonstration programs for tactical applications are conducted or supported by the PEO(CU).[13] These continuing activities combine emerging technologies with operational concepts to provide an expanding menu of capabilities for fielding aboard the DoD's evolving family of UAVs.

The FY 1996 payload demonstrations that were reported in FY 1997 are combined with FY 1997's demonstrations in the table below. During this time frame, the PEO(CU) also participated in several operational exercises, to provide more convincing demonstrations of UAV and payload capabilities and utility. These activities are tabulated on p. 9.

[13] Specific payload and subsystem applications within the HAE UAV ACTD are conducted by DARPA and are covered in the *Global Hawk* and *DarkStar* program descriptions.

Demonstration Payload	Potential Mission Application	Host UAV	Report
Coastal Battlefield Reconnaissance and Analysis (COBRA)[a]	- Detect mines (day / limited visibility)	*Pioneer*	Nov 96
Signals Intelligence (SIGINT) Payload[a]	- Locate/ID enemy ground emitters	*Hunter*	Nov 96
Radar Jammer Payload[a]	- Jam enemy ground radars	*Hunter*	Nov 96
Communications Jammer Payload[a]	- Jam both radios and data links	*Hunter*	Nov 96
ALE-47 Dispenser Integration:			
– Remote control standard payload dispenser system[a]	- Non-lethal crowd control	*Exdrone*	Jun 97
		Hunter	(Jan 98)
		Pioneer	(Mar 98)
– Tactical Meteorological Dropsonde System (T-Drop)[a]	- Demo of near-real-time weather data from remote/denied areas	*Predator*[b]	Sep 97
		Pioneer	(Mar 98)
– Chemical Agent Dual Detection Identification Experiment (CADDIE)[a]	- Chemical agent detection	(TBD)	(TBD)
Anti-Personnel Land Mine Replacement[a]	- Force protection	(TBD)	(< 2 yrs)
Orion Wideband Intercept Relay[a]	- Find, relay ground comms emitters	*Hunter*	Jul 97
Versatron DS12 with Laser Range Finder	- Target location	*Pioneer*	Jul 97
Versatron DS12 with Laser Designator[a, c]	- Target designation	*Pioneer*	Jul 98
Tactical Remote Sensor System (TRSS)	- BLOS ground sensor relay	*Pioneer*	(TBD)
Airborne Standoff Mines Detection System (ASTAMIDS)	- Mine countermeasures	*Hunter*	(TBD)
Synthetic Aperture Radar (SAR)	- All-weather reconnaissance	*Pred / Out*	(TBD)
Precision Location (sensor and algorithms)	- Precision target location	*Pioneer*	(TBD)

[a] Sponsored by other agencies [b] Mounted in a conformal pod [c] Possible common support for T-Drop sensor relay

The Army's Night Vision Electronic Sensors Directorate (NVESD) is testing a variety of EO/IR and Measurements and Signals Intelligence (MASINT) sensors aboard four *Sentry* UAVs recently acquired from S-TEC Corp. Although the immediate customer is the Army's Intelligence and Security Command (INSCOM), these efforts will ultimately benefit tactical UAV users.

TCS Demonstration Aboard USS Tarawa

TCS was integrated aboard the USS Tarawa for a demonstration during the November 1997 Fleet Exercise (FLTEX), using the *Gnat 750* (with MUSE as a backup simulation tool). In addition, data was received from a *Pioneer* flown off the USS Denver. TCS Levels 2 and 4 (direct data receipt, and UAV and payload control, respectively) were successfully demonstrated. TCS disseminated video imagery and telemetry data via closed-circuit television (CCTV) and the Joint Defense Intelligence Support System (JDISS). Additionally, UAV data was transmitted via tactical communications to users for incorporation into the exercise.

Multiple UAV Simulation Environment (MUSE)

MUSE was developed by the Joint Technology/Systems Integration Laboratory (JTSIL) to provide real-time operator-in-the-loop simulation of multiple UAVs. MUSE provides a realistic UAV environment for UAV systems integration, exercises, experiments, demonstrations, CONOPS development, and training. It is hosted on Silicon Graphics Onyx and Sun SPARC computer hardware and is fully transportable to user locations. The system currently simulates operations of *Pioneer, Hunter, Outrider, Predator,* and prototype TCS; it will incorporate HAE UAVs in FY 1998. MUSE systems are currently provided at six Service locations.

Technology Programs

In January 1996, the USD(A&T) first discussed ten primary "enabling technologies and architectural concepts that are needed to build dominant battlefield cycle times." All are relevant to airborne reconnaissance, and most are currently being applied to or planned for various programs. Their UAV applications are shown in the table below.

Application of Key Enabling Technologies to UAVs

Key Enabling Technologies:	*Outrider*	*Predator*	*TCS*	*Global Hawk*	*DarkStar*	*CGS*
1. Advanced Processing (On-/Off-Board Processors)	X	X	X	X	X	X
2. Automatic Target Processing (Imagery Analysis Productivity Tools)	X	X		X	X	
3. Common Grid Reference (Enhanced Data Fusion)			X	X		X
4. Distributed and Open Architectures (e.g., JASA)			X	X		X
5. Sequential Application of Off-Board Collectors				X		
6. Data Compression	X	X	X	X	X	X
7. Very Large, Dynamic, Object-Oriented Data Bases						
8. Data Storage			X			X
9. Data Dissemination (interface to user/warfighter)		X	X	X	X	X
10. Planning Analysis Tools (e.g., Mission Planning tools)			X			X

DARO's Airborne Reconnaissance Technology Focus

DARO's "systems" approach to technology applications leverages both commercial and other government technologies to maximize its investment. Its three major focus areas are Advanced Technology, Advanced Sensors, and Communications (Common Data Link).

Advanced Technology

This program funds research, advanced development and demonstrations of maturing technologies to facilitate their applications and a transition to DARO's future objective airborne reconnaissance architecture. The current technology transition activities most applicable to UAVs are shown below.

Technology Transition Program Activity

FY 1997	FY 1998	Remarks
Reconfigurable Pods		Near-term focus on manned recce; UAV applications later
Precision Geolocation		**SIGINT:** Cooperative geolocation demonstrations **IMINT:** Development of passive radar tags and imagery registration techniques
SIGINT Upgrades	SIGINT Technology	Modular, incremental JSAF approach. Multi-use antenna study for SAR / Comms / SIGINT
Automatic Target Recognition (ATR) & Correlation		Demos of moving target exploitation performance and functionality in JSTARS virtual testbed. Demo Intelligent Bandwidth Compression (IBC) real-time application to U-2 and *Global Hawk*. Transition of semi-automated IMINT processing (SAIP) ACTD to operations
Exigent Target Detection		Conduct evaluation tests of hyperspectral imaging (HSI) sensors on a UAV
CDL and Advanced Technology		Enabler of UAV (and manned system) interoperability
High-Data-Rate (HDR) Uplinks and Crosslinks		Complete and demo laser terminal air-to-air
Heavy Fuel Engines	Common Systems Development [a]	Support development of advanced HFE for UAVs
Integrated Avionics	Common Systems Development [a]	Integrated, tested and now acquiring Modular Integrated Avionics Group (MIAG) for *Pioneer*
MSAG	Common Systems Development [a]	Completed the prototype Active Array antenna (MSAG = Multifunction Self-Aligned Gate)
Framing Reconnaissance Cameras	Common Systems Development [a]	Developing IR versions of 4-mega-pixel (MP) and 25-MP EO framing cameras. Continuing multispectral and compression algorithm technology developments

[a] DARO's HFE request not funded in FY 1998 Appropriations Act (DARPA may fund for FY 1998); MIAG funded in *Pioneer;* MSAG and cameras funded under DARO's Advanced Technology program.

UAVs' Operational Advantages Are Fueling an Expanding Demand

Common Data Link (CDL)

Description: The CDL and Tactical CDL (TCDL) provide configuration-controlled and standardized wideband, digital, secure communication paths between multiple reconnaissance sensors and their users (e.g., *Predator, Global Hawk,* and *DarkStar).* TCDL also supports development of the lighter-weight lower-cost units for the TUAV *(Outrider)* and *Predator.*

FY97 Highlights	FY98 Plans
• Continued Airborne Information Transmission (ABIT) preliminary design for platforms • Began Tactical CDL development • Leased comsats supported *Predator* and HAE UAV activities	• Continue TCDL development • Support UAV testing, training, ing, and deployments

Advanced Sensors

Description: This program funds improved sensors from successful Advanced Technology proof-of-concept efforts and conducts sensor prototype demonstrations, which are turned over to Services for procurement and platform integration. It also identifies multispectral imaging (MSI) technologies for sensor system upgrades.

FY 1997 Highlights	FY 1998 Plans
• Improved *Predator* image quality and utility • Increased night contrast • Eliminated motion artifacts	• Improve *Predator* system location accuracy, and general system optimization

The following table summarizes other UAV-related technology projects that DARO funds or otherwise supports, in cooperation with Service or other government agency initiatives.

Current UAV Technology Applications

Heavy Fuel Engine (HFE)

- Objective: Provide UAVs with a safe, readily available fuel for DoD system commonality
- Status: Following U.S. and international developments to satisfy an urgent need for reliable, lightweight (1 lb/hp) HFEs for UAVs

Joint SIGINT Avionics Family (JSAF)

- Objective: Open-architecture suite of sensors based on Joint Airborne SIGINT Architecture (JASA) (currently for manned aircraft, but potentially applicable to UAVs)
- Status: Development continues, but UAV engineering and compatibility studies postponed

Laser Designator/Rangefinder (LDRF) Payload

- Objective: Accurate targeting for precision guided munitions (PGMs) without risk to aircraft or ground spotters
- Status: An off-the-shelf payload was integrated into a *Hunter* and successfully demonstrated in FY96. An LDRF demonstration is being planned for *Outrider*

Mine Countermeasures Payload

- Objective: UAV-borne mine detection capability to avoid risk to ground troops and naval forces.
- Status: Integration of the Coastal Battlefield Reconnaissance and Analysis (COBRA) payload on TUAV by early 2003

Downsized Synthetic Aperture Radar (SAR) (Tactical SAR)

- Objective: Affordable, lightweight SAR sensors to increase UAV flexibility and performance.
- Status: Planning integration in TUAV in 2002. Payload includes 0.3 and 1.0 m resolution spot mode

Communications/Data Relay Payload (CRP)

- Objective: Routinely use UAVs for airborne relay to free manned aircraft for other missions
- Status: A CRP was successfully demonstrated aboard a *Hunter* in FY96

Air Vehicle Electromagnetic Interference (EMI)

- Objective: Design and produce air vehicles whose EMI environment allows successful SIGINT, communications relay operations
- Status: Initial *Predator* EMI reduction effort completed successfully

Global Positioning System (GPS) Pseudolites

- Objective: Enhance warfighter resistance to GPS jamming by rebroadcasting GPS data from UAVs
- Status: Continue tracking Navy and DARPA GPS pseudolite programs

Interferometric SAR (IFSAR)

- Objective: Improve geolocation accuracy by developing a single-pass HAE IFSAR capability
- Status: Joint effort with the ACTD sensor development by 2002

Wideband SAR (Foliage Penetrating [**FOPEN**] **Radar**)

- Objective: Improve all-weather detection of targets concealed by foliage or camouflage
- Status: Continue to develop a sensor for integration on TUAV by 2001

Focal Plane Arrays (FPAs)

- Objective: Develop large-format FPAs for improved imaging compared to film or line scanning sensors
- Status: 25-Megapixel FPAs demonstrated

Hyperspectral Imaging (HSI)

- Objective: Improved detection of hidden or camouflaged objects by spectral discrimination
- Status: Hyperspectral sensors for *Predator* to permit real-time tactical cueing of on-board cameras

Video Imagery (per DSB Task Force on Improved Applications of Intelligence to the Battlefield, Jul 96)

- Objective: Improve video image quality, and provide cataloguing, retrieval and exploitation capabilities
- Status: Improve *Predator* video to provide advanced reconnaissance, day/night and adverse weather capabilities, BDA, and battle management functions

Automatic Target Recognition (ATR)

- Objective: Improve target discrimination in wide-area imagery, and minimize data link bandwidth
- Status: Joint DARO/DARPA program to develop multisensor exploitation testbed employing spectral, moving target exploitation (MTE), FOPEN ATR techniques

Common Systems Development

- Objective: Pursue development and production of systems common to the tactical family of UAVs
- Status: Support of testing, system integration and subsystem development, including UCARS and MIAG. Demonstration of alternative UAV technologies and concepts (e.g., VTOL and HFE)

DARPA Technology Initiatives

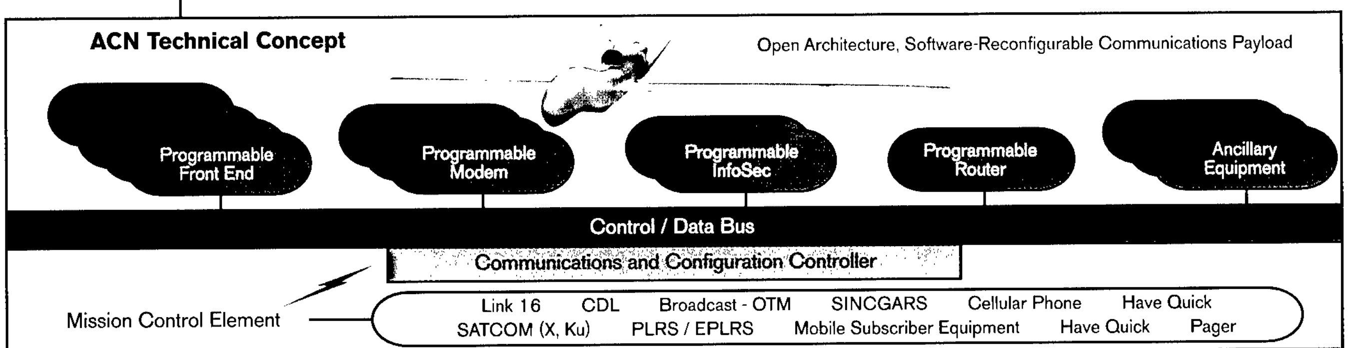
Airborne Communications Node (ACN)

DARPA's ACN program will develop a prototype communications payload for deployment on long-endurance platforms, using advanced technologies also under DARPA development.

ACN's theater-wide communications will help share information within and among joint forces. Its modular, software, reprogrammable radio and open system architecture will support multiple communication services, to include internet-like networking for joint warfighters. It will provide new mobile routing of cellular/personal communications services, and extended VHF and UHF radio capabilities, thereby enabling over-the-horizon connectivity for isolated or rapidly moving forces. It will feature robust gateways, bridging, routing, broadcast, paging, and multimedia services. The network may be extended to other aircraft through air-to-air crosslinks to form a self-organizing backbone. ACN's value will be seen in rapid force projection, where its network synchronism and multiple services will improve the battle management of early entry and general expeditionary forces.

FY97 Highlights	FY98 Plans
• Completed four technology studies • Contracted for Advanced Digital Receiver and RF-tunable MicroElectro-Mechanical System (MEMS)	• Contract for expanded frequency coverage for the RF MEMS filters, advanced digital transmitter and power amplifier, and an advanced infosec module and router[a]

[a] All these modules are designed around a peripheral control interface (PCI) bus and credit card-sized Personal Computer Memory Card International Association (PCMCIA) module.



Micro-Air Vehicles (MAV)

Micro Air Vehicle scale model

DARO is supporting a DARPA initiative to develop a micro-air vehicle (MAV), defined as a UAV measuring less than 15 cm (≈ 6 inches) in any dimension while carrying a miniaturized payload, simple avionics, and a communication link. This new class of UAV would be ideal for employment by small, mobile units operating in environments such as urban areas or unconventional operations anywhere. At the same time, the MAV presents a combination of technical challenges, as the sub-15-cm régime involves changes in the way things fly in terms of the physics of aerodynamics and flight control. Modern materials, microsensors and study of the flying techniques of small birds and insects will all contribute to MAV development.

FY 1997 activities included: a military applications workshop at Ft. Huachuca, AZ (October 1996); an emerging technologies seminar at Georgia Tech Research Institute, GA (February 1997); and a conference on targeting and gun-launched applications at Aberdeen Proving Grounds, MD (April 1997). Longer-term challenges include integration of the multiple new technologies, and assuring both affordability and simplicity of operation and support in the field. DARPA plans to spend $35 million during FY 1997 – 2000 on MAV feasibility determination. In late 1996, it awarded nine Small Business Innovative Research Phase I contracts of up to $100,000 each.

Issues and Challenges

Last year, our major challenges were in the areas of acquisition, technology, architecture, management approach, and operations. We have made significant progress in each of these areas, but new aspects emerge. As FY 1997 phases into FY 1998, they are as follows:

Acquisition Oversight

Our family of UAVs continues to be the best approach to meeting the JROC's multiple requirements. Sustaining *Pioneer* and using *Hunter* until new systems are available reflects a DoD-wide appreciation for UAVs' value. *Predator* is now firmly in production, the result of a solid post-ACTD transition process. The *Outrider* program has incurred a number of schedule delays, but increased oversight by the USD(A&T) and recent flight testing indicate that progress is being made. The HAE UAVs' flights are now taking place in FY 1998, after prudent delays to resolve technical issues. Both TCS and HAE CGS are being brought along to support their tactical and HAE UAVs and integrate their products with the C4I infrastructure.

The challenges that remain are those of all acquisition programs: how to "manage uncertainty" while bringing newly integrated systems to operational status and meeting program objectives in the standard areas of performance, cost, and schedule.

Technology

A combination of changing national roles and force structure in the face of stringent budgets enhances the role of technology as enabler of future capabilities. Many of the high-leverage technologies we have been maturing are now parts of subsystems and payloads that are being procured for fielded use (e.g., UCARS and MIAG). In turn, others are emerging for near-term focus and application in their turn (e.g., Tactical CDL). We will approach payload development in light of the JROC's emerging guidance, and in turn project new and varied military uses for our basic UAV platforms (e.g., Boost Phase Intercept, Communications UAV, and Uninhabited Combat Air Vehicle). Finally, integration of technologies is, in effect, another technology and offers as much challenge as any other aspect of system development.

Architecture

The DADT's interim report provides a first view of DARO's Objective Architecture and force structure projection for the 2010 time frame, as envisioned in DARO's *Integrated Airborne Reconnaissance Strategy* of 1994. Force mix and inventories sized for two MTWs should also suffice for routine and contingency operations. The report's roadmap projects eventual replacement of manned platforms by HAE UAVs for high-altitude missions and broad augmentation of manned platforms by *Predator* and tactical UAVs for medium- and low-altitude missions. The challenge architecturally will be to ensure (1) that Service UAV acquisition programs continue to meet joint requirements, and (2) that system interfaces and product interoperability factors continue to meet the needs of warfighters for comprehensive, accurate and timely information. The challenge analytically will be for DARO to develop and validate even more capable MS&A tools and techniques to support complex architectural and system-level trades as airborne reconnaissance migrates to the 2010 time frame.

Management Approach

Both DARO and the Department are accommodating to the recent changes in DoD organizational structure and oversight roles. What remains well proven, however, is the need for continuing, unified oversight of the many resource and functional aspects of airborne reconnaissance. The central roles played by DARO, the Joint Staff and many current DoD-wide processes have done much to rationalize airborne reconnaissance services and products for the warfighter, but the real payoff for UAVs will be in the projected fielding of those UAVs currently in ACTD status.

Operations

The continued presence of *Predator* over Bosnia and the series of FY 1997 exercises and demonstrations, in which UAVs proved their worth many times, are changing the way commanders view their battlefield. Ground commanders want responsive collection systems that provide critical information to enhance battlefield situational awareness, and UAVs must also show that they are sustainable logistically and can interoperate functionally with existing forces and C4ISR environments. Four operational subareas are noteworthy: multiple-UAV operations, airspace management, marinization, and imagery archival and retrieval. They are addressed in the following table.

Challenges	Activities
Multiple-UAV Operations *"We are just beginning to understand the operational impact of multiple-UAV operations...."* *(FY 1996 Report)*	*Hunter* first demonstrated multiple-UAV operation during a single mission in Apr 91, when one *Hunter* served as an airborne data link or relay, for control of another *Hunter,* during test. In April 1996, *Hunter* performed successfully as an airborne UHF/SINCGARS data relay: one *Hunter*, controlled from a forward control station, collected imagery while a second *Hunter* acted as its airborne data relay. General Atomics is now developing a similar capability with its *Gnat 750XP,* but from a single ground station. The company will enhance *Predator* operations in 1998 by adding the ability to control two *Predators* in flight simultaneously, one on-station and one en route to/from the operations area, from the same ground station. Thus, from initial multi-*Hunter* control (sometimes by multiple GCSs), multi-*Predator* control processes are under development, to include their operation through civil air space. In addition, concepts for operating UAV wingmen via a manned "mothership" and autonous UAV flights are being explored by Boeing and other contractors
Airspace Management *"We are continuing both national and international [airspace] coordination"* *(FY 1996 Report)*	The DoD Policy Board for Federal Aviation and the Air Force Flight Standards Agency (AFFSA) are leading DoD discussions with the Federal Aviation Administration (FAA) to allow unaccompanied UAV flights in the National Airspace System (NAS). Key issues to emerge from two 1997 meetings involve redefining the "see and avoid" concept, UAV-to-pilot ratios, inflight emergency procedures, and filing of clearances. New regulations (revised Order 7610.4) are now in negotiation for implementation in 1998
UAV Marinization *"...marinization seeks to provide UAV support for deep-water, littoral and amphibious operations..."* *(FY 1996 Report)*	In its *Predator* marinization feasibility study, the Navy examined adapting it for at-sea launch and recovery, as well as land-based maritime support. While modifications for sea-basing were deemed too complex and costly, the introduction of TCS aboard ships will provide capabilities to receive imagery and control the UAV's sensor and flight route without costly modifications to either ship or UAV. A TCS aboard the USS Tarawa (LHA-1) has already demonstrated receipt of imagery from both a *Gnat 750* and a *Pioneer* while operating off San Clemente Island, CA. For the next year, the Navy and Marine Corps will evaluate an *Outrider* system for maritime operations while concurrently exploring VTOL options and technologies
Imagery Archival/Retrieval *"We will need very large, dynamic, object-oriented databases...to store and transport imagery to...the warfighter..."* *(FY 1996 Report)*	During FY 1997, working with DARO the UAV JPO prototyped the inclusion of metadata in a *Predator's* data stream. The data were embedded in the closed-caption data fields. To ensure interoperability, DARO worked with the NIMA Video Working Group to develop a metadata standard for all video systems. The inclusion of metadata within the video stream enables automatic searching through the data archive to find the video clip of interest. A fully automatic archival system of the video data should now be feasible

Summary

The several challenge areas outlined above have all shown progress during the past year. At the same time, each issue resolved contains the seeds of a new challenge to be met. DARO's role has been to identify these cross-cutting, system- and architectural-level issues and provide guidance and oversight for their resolution, and we look forward to meeting the challenges of FY 1998 and beyond.

Director's Conclusion

Many challenges remain in UAV development if we are to continue to improve our performance of the intelligence, surveillance and reconnaissance mission and to develop new roles for the 21st century.

Enduring Challenges include:

- **Acquisition oversight** — the assurance of Department-wide coordination of all the players and processes that lead to the fielding of interoperable, sustainable and affordable UAV systems, as a growing part of our ISR capability. Cost is on an equal basis with performance.
- **Technology** — in all its facets, the great enablers of our evolving systems.
- **Architecture** — the emerging framework within which our UAV assets will play increasing roles, in conjunction with more traditional manned and overhead systems.
- **Operations** — the full-spectrum arena within which our UAVs will be fielded, our current focus is on multi-UAV activities, airspace management (especially coexistence with manned aircraft), marinization approaches to meet deep-water operational requirements, and the management of great quantities of imagery products and data.
- **Effective modeling and simulation tools** — to help quantify the military utility of UAVs and of airborne ISR generally. These techniques in turn become the bases for force mix trade studies to identify the optimal mix of assets to meet operational needs of the next century.
- **Control of program growth** — which involves both protecting our developmental UAV systems from "requirements creep" and not letting new concepts and missions drive our programs beyond performance capabilities. Our ongoing review of *Outrider* is sorting out how to proceed in meeting a broad range of multi-Service requirements, while our cautious approach to the impending HAE UAV flights indicates that our first focus must be on basics: first the birds have to fly and meet ACTD criteria; then their full capabilities can be explored and potentially expanded.

System Objectives include:

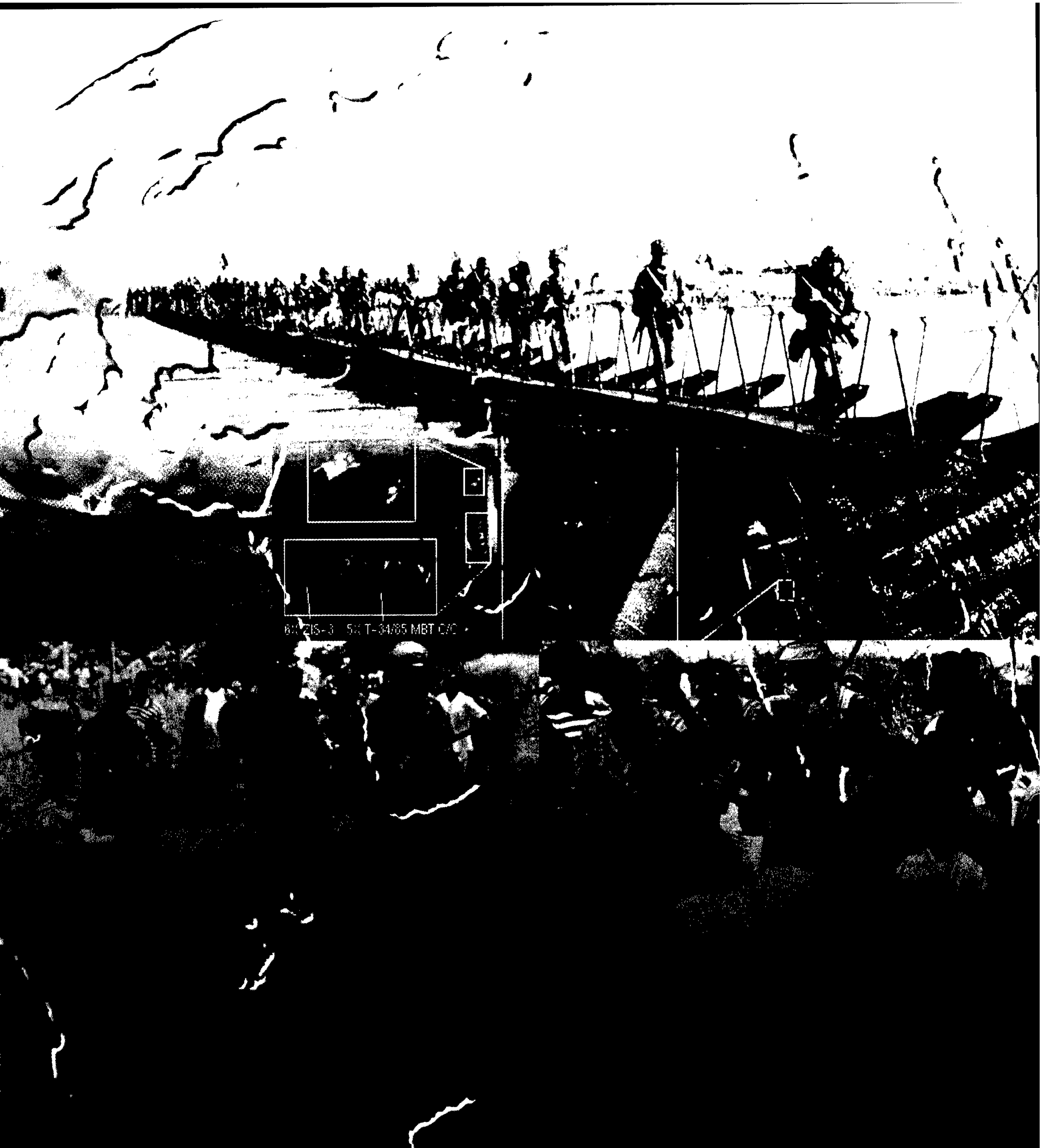
- **An HFE for tactical UAVs** — As part of the review process for the *Outrider* ACTD, HFE development was removed from the Tactical UAV program and initiated as a separate development effort. An HFE is critical to tactical UAV operations in that (1) it would use a more safe, reliable fuel already common to other aircraft systems, and (2) use of a common and safe fuel is crucial for UAVs operated and supported aboard ship.
- **Improved video product management** — We have begun to discover the value of video intelligence. Some estimates project that in the early 21st century over 90% of the pixels we collect will be from video sources. However, we have not yet resolved the problem of how to store, index and quickly retrieve the products. MPEG video compression will help reduce the video storage burden, but search and retrieval functions must also keep pace.
- **All-weather intelligence for the warfighter** — A continuing operational need is for accurate and timely intelligence regardless of weather. For this, we need to use synthetic aperture radar (SAR) techniques to see through clouds. As current SAR systems are relatively heavy, we need a SAR system sized for use on tactical UAVs.
- **Reduction of UAV vulnerabilities** — Now that UAVs are flying and meeting mission needs, we need to protect both their C2 and data transmission links against jamming, as well as consider counters to physical threats.

These activities all take time, money, thoroughness, and patience. They also take a family of UAVs, just as more than one aircraft is needed to meet multiple mission requirements. Any one program's fortunes may fluctuate from year to year, but overall we have made substantial progress. *Pioneer, Hunter* and *Predator* are flying routinely. *Outrider* is defining its capabilities. The HAE UAVs should be airborne shortly. ***A promising future for ISR is just around the corner — to support both the warfighter and our broader national objectives.***

UAVs are a key element within the concept of Information Dominance. As an office of the Secretary of Defense, the DARO's first responsibility is to develop and maintain the DoD's integrated airborne reconnaissance architecture as a framework for the development and acquisition of improved airborne reconnaissance capabilities.

DEFENSE AIRBORNE RECONNAISSANCE OFFICE

Supporting the Warfighter



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